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MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

A Moral Antiseptic

If, in the last hundred years, the whole material setting of civilized life has altered, we owe it neither to politicians nor to political institutions. We owe it to the combined efforts of those who have advanced science, and those who have applied it.

It may seem fanciful to find in a single recent aspect of this revolution an influence which resembles religion or patriotism in its appeals to the higher side of ordinary characters, especially since we are accustomed to regard the appropriation by industry of scientific discoveries merely as a means of multiplying the material conveniences of life . . . The energies thus aroused may affect the whole character of the community, spreading the beneficent contagion of hope and high endeavor through channels scarcely known to workers in the fields most remote; if all this be borne in mind, the relation of science and industry may perhaps seem not unworthy of the place among moral antiseptics which I have tentatively assigned it.

ARTHUR BALFOUR

(Quoted by Dr. Hollis in this issue; see p. 443)

AUGUST 1924

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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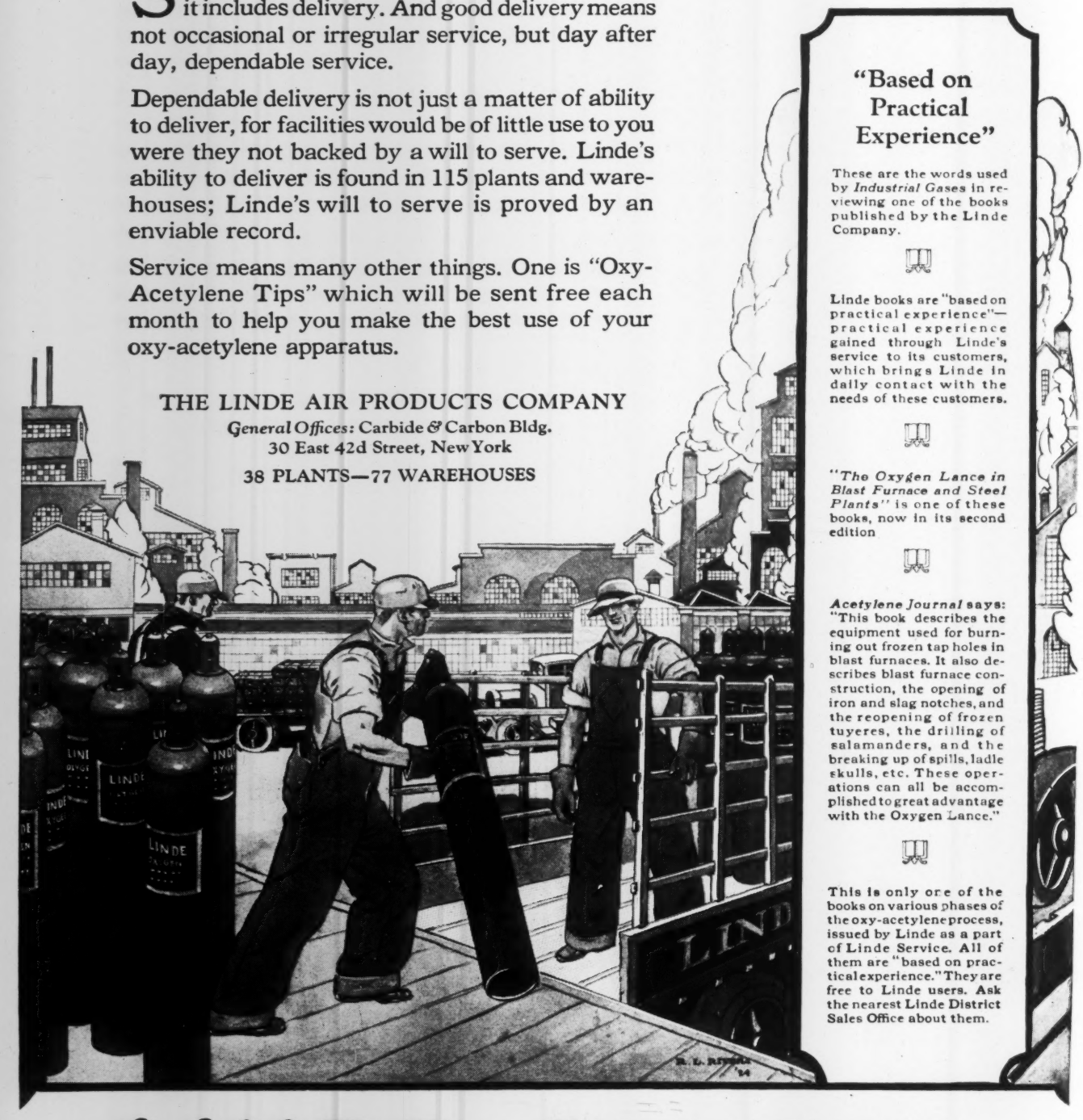

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B. Nagelvoort

T. D. Perry

T. T. Read

A. C. Danks

Earl McFarland

Contributors to this Issue

At the Student Branch Conference of the Spring Meeting of The American Society of Mechanical Engineers, an account of which is the leading feature of this issue, the speakers included Dean D. S. Kimball, Mr. J. L. Harrington and Dr. Ira N. Hollis, all of whom are past-presidents of the A.S.M.E.

Ira N. Hollis, President of Worcester Polytechnic Institute, was graduated from the U. S. Naval Academy in 1878. He was in active service until 1893, when he resigned to accept the professorship of engineering at Harvard University, where he taught for twenty years. In 1913 he accepted the presidency of Worcester. Dr. Hollis holds the honorary degrees of A.M. from Harvard, L.H.D. from Union, and Sc.D. from Pittsburgh.

Dexter S. Kimball, since his graduation from Leland Stanford Jr. University in 1896, with the exception of a few years spent with various engineering firms, has been a member of the faculty of Cornell University. He was professor of machine design and construction until 1915, and since that time has occupied the chair of industrial engineering. He became dean of the College of Engineering in 1920.

John Lyle Harrington has for many years been in close contact with engineers in various branches of the profession. He was graduated from the University of Kansas with the degrees of A.B., B.S. and C.E. Later he received his M.S. from McGill University. In his professional life he has engaged in the design and supervision of the construction of large bridges.

* * * * *

Thomas T. Read, who contributes the article on Power from the Earth's Heat, is Safety Service Director of the U. S. Bureau of Mines. Dr. Read is a graduate of the School of Mines of Columbia University, and has also received the degree of Ph.D. from Columbia. After a varied experience in the United States he went to China in 1907 as professor of metallurgy at Pei Yang University, Tientsin, returning to America early in 1911 as associate editor of the *Mining and Scientific Press* of San Francisco. In 1916 he became chief of the Service Division of the technical department of the New Jersey Zinc Co., and during the War was chief of the reviewing branch of the Estimates and Requirements Division of the Army Ordnance. Since the war he has been with the U. S. Bureau of Mines. In 1922 he was representative of the Interior Department with the American Commission to the Brazilian Centennial Exposition, and while in Brazil studied the problem of cooling the workings of the deepest mine in the world, the St. John del Rey.

* * * * *

A. C. Danks, author of the paper in this issue on The Gas Engine in the Steel Industry, is president of the Ashmead-Danks Co., Cleveland, Ohio. Mr. Danks was born in Kentucky. He was educated in the public schools of Kansas and the Carnegie Institute of Technology, receiving his early mechanical training in his father's machine shop. This training was continued in the plants of the Inland and Illinois Steel Companies. He became particularly interested in the gas engine and after a short period with the Miller Gas Engine Co., Springfield, Ohio, was employed as erection engineer by the American Crossley gas engine. His next position was with the Westinghouse Machine Co. where he brought out the first gas engine built to operate on blast-furnace gas. For a long period Mr. Danks was connected with the Braddock power plant of the Carnegie Steel Co., and then was actively engaged for some time in many large installations. About two years ago he became president of the Ashmead-Danks Co., of Cleveland.

* * * * *

Major Earl McFarland, Commanding Officer of Springfield Armory, is the author of the paper on Manufacture of the Bolt of the Springfield Rifle. Major McFarland was graduated from West Point in 1906 and received his degree of M.E. from Worcester Polytechnic Institute in 1923. Since 1910 he has been on duty with the Ordnance Department in connection with the design and manufacture of ordnance materials. Some years prior to the war he was assigned especially to work in connection with the procurement of machine guns. Since 1917 Major McFarland has devoted practically all of his time to the subject of machine guns, rifles, and other small-arms products. He was awarded the Distinguished Service Medal for especially meritorious and distinguished services in connection with the design, development, and production of machine guns during the World War. Major McFarland has recently been assigned as professor of ordnance and gunnery at the U. S. Military Academy and will assume his duties shortly.

* * * * *

B. Nagelvoort and Thomas D. Perry are co-authors of the paper on Lumber Handling in an Automobile-Body Plant. Mr. Perry received his A.B. from Doane College, Nebraska, in 1897, and his B.S. in mechanical engineering from the Massachusetts Institute of Technology in 1900. After two years as maintenance engineer for the Library Bureau in Boston, and four years as manager of the index card department, Macey Co., Grand Rapids, Mich., he became secretary and business manager for the Board of Education of that city. Since 1911 he has been vice-president and manager of the Grand Rapids Veneer Works.

Mr. Nagelvoort was born in Surabaia, Java, in 1876. He was brought to this country when a child and until twelve years of age lived in Western Nebraska, then moving to Detroit where he attended the schools of that city. He learned the patternmaking trade at the Detroit Shipbuilding Co. where he became interested in the engineering profession. He was graduated from the University of Michigan in 1906, working his way through college, and then spent two years with the Murphy Iron Works of Detroit as draftsman and erecting engineer. For twelve years Mr. Nagelvoort was connected with the Packard Motor Car Co. as mechanical engineer in body work, resigning in 1922 to accept a similar position with the Towson Body Co., Detroit, where he is now located.

* * * * *

R. L. Sackett, Dean of the School of Engineering, Pennsylvania State College, since 1915, is the author of the paper on Making Industry Attractive to High-School and College Students, presented at a Conference of the Committee on Education and Training for the Industries at the A.S.M.E. Spring Meeting. Dean Sackett is a University of Michigan graduate, class of 1891. Previous to 1915 he was professor of sanitary and hydraulic engineering at Purdue.

Dr. Hollis also presented a paper at the conference on Labor as Means of Social Salvation.

MECHANICAL ENGINEERING

Volume 46 August, 1924 No. 8

The Influence of Engineering

Past-Presidents Hollis, Kimball, and Harrington of the A.S.M.E. State the Chief End of the Profession To Be an Enlarging Living Moral Force for Humanity

"THE mob looks on the engineer as half comic hermit and half super-plumber, and naturally he shares none of the hero worship given to eminent sportsmen, comedians, and politicians." The foregoing is by a speaker at the recent World Power Conference in London, who in a plea for the right of the public to know and understand something about the advances in science and engineering and their meaning to civilization, emphasized the fact that such a knowledge and understanding would inaugurate a popular demand for the advancement of mechanical science. He further stated that if this is to be brought about, we must overcome the popular conception of the engineer as a sort of tame magician whose tricks are rarely amusing. To do this the engineer must understand his profession and that implies thorough understanding of the obligations he owes to the profession itself and the duty the profession has to the public.

The addresses that follow are valuable discussions of this important relationship. They were presented before a conference of representatives of Student Branches at Cleveland on Wednesday, May 28, and while planned to be of interest primarily to students, the remarks should inspire full-fledged members of the profession to greater appreciation of the obligations and opportunities that the profession offers.

The Influence of Engineering

By IRA N. HOLLIS,[1] WORCESTER, MASS.

IN ONE of his essays, Arthur Balfour, a former prime minister of England, has called attention to that activity which is fairly representative of the engineering professions. He says:

> If, in the last hundred years, the whole material setting of civilized life has altered, we owe it neither to politicians nor to political institutions. We owe it to the combined efforts of those who have advanced science, and those who have applied it.
>
> It may seem fanciful to find in a single recent aspect of this revolution an influence which resembles religion or patriotism in its appeals to the higher side of ordinary characters, especially since we are accustomed to regard the appropriation by industry of scientific discoveries merely as a means of multiplying the material conveniences of life. . . . . The energies thus aroused may affect the whole character of the community, spreading the beneficent contagion of hope and high endeavor through channels scarcely known, to workers in the fields most remote; if all this be borne in mind, the relation of science and industry may perhaps seem not unworthy of the place among moral antiseptics which I have tentatively assigned it.

This plainly puts engineering, as the profession which applies science and power to the uses of man, in its proper relation to the growth, the morality, and the permanency of our nation. It does not for one moment consent to having the product of our brains and hands set aside as sordid materialism, as sometimes suggested to our philosophers. It would give to every student an understanding of his profession and a reverence that ends in service as the highest ideal. A thoughtless and ignorant public cannot, under Mr. Balfour's finding, classify us as the utilitarians who work only in machinery and in soulless materials. The activity by which men lived in their first appearance on this earth was not exactly the application of science but the use of the hands in what has since grown to be our chief reliance for food, shelter, and clothing. By hand work the ideals and morality of society have been as much built up and maintained as through religion, and far more than through the wanderings, or guesses, or speculations of philosophers.

We can accept a code of ethics in relation to our service, and we can express ideals through our work as elevated as anything to be found in literature, if we can only bring ourselves to think so and to understand the means by which all society has been developed into its present advanced stage. Let us remember, however, that we express ourselves in our work. In 1900 years almost nothing has been done to clear away the misunderstandings or the struggles over religion. We have accepted the Christian religion but not the religion of Christ, and even now we are quarreling over interpretations of texts that have no great importance, in the attempt to live the life of the Master. In the meantime, mankind has advanced immeasurably through the use of the earth's energy and resources. Also, through machinery, we have opened the gate to a larger idealism, a finer morality, and a far better relation of man to man.

Nations fall when their natural resources have been used or wasted, and only through the applications of science can we learn how to conserve them. Of all nations it may be said, "Honor thy inheritance, that the days of thy children may be long in the land that God has given them." Through our profession we can learn this if we listen to the voice hidden within every product of man's hand. It is there, if we can only take our minds away from material results and hear the higher truth that man gets his satisfactions from the work itself. To make a living by the practice of engineering, and to make of engineering an enlarging, living, moral force for humanity, is the chief end of our profession. We know well the first; we have to learn the second, but we forget that the second is just as essential if humanity is not in the end going to fail. Our education must not cease when we have learned to earn our living through technical science; in other words, we when have finished college. If "necessity is the mother of invention," invention is in its turn the mother of service and the creator of a better civilization.

One of the shortcomings of our educational system for applied science is too great attention to technicalities, the illustrations of those fundamentals which tend not only to enlarge the mind but to give us a larger reverence for the universe as it is. We lack in the schools almost all reference to the history of our own profession. We fail to understand its place in the growth of civilization, we fail even to understand it as a moral force, and we accept too readily the finding of the ignorant.

It has been suggested to the Council of The American Society of Mechanical Engineers that a money prize be offered to the student handing in the best paper of the year on The Place and Influence of Engineering toward the Permanency of Nations. This would mean not a laboratory experiment, but a larger study of history, in order that the young people who are going into the engineering professsion may obtain a better grasp of citizenship and the real influence of their profession, and through that they may acquire a large conception of service, which, after all, is at the bottom of all success in professional life of any kind. It may require some months to work out the conditions of such a prize and to suggest the exact title of subjects. It can readily be done, however, if The American Society of Mechanical Engineers will turn that way. We already have an endowment sufficient to provide for one prize, and we may obtain larger endowments in the course of time. It is hoped that this may work out to the end that our young men leave their colleges with that broader education on which only a high profession may be based.

When Mr. Eliot wrote for the inscription on the new post office in Washington:

[1] Pres., Worcester Polytechnic Institute.

Messenger of sympathy and love,
Servant of parted friends,
Consoler of the lonely,
Bond of the scattered family,
Enlarger of the common life,

he must have had in his mind the agency that has made the beautiful service therein described possible, and we who are in engineering have every right to believe that our profession is the supporter of all that this says. Rightly viewed, we have a large share in creating the nobler humanity that must spring out of the righteous use of materials.

Fundamental Purposes of the Society

By DEXTER S. KIMBALL[1], ITHACA, N. Y.

ONE of the most deeply rooted impulses of the human heart is the desire to "belong." From time immemorial men have banded themselves together for one purpose or another. This impulse probably has its roots in man's gregarious disposition, and in primitive times the necessities of the hunt or war or simple self-protection deepened this need into a habit. We are all "joiners" in some degree, and with some people this desire is almost a mania. The daily papers are filled with accounts of organizations of many kinds, and their grandiose titles and no less grandiose and high-sounding names for their officers are certainly a study in human psychology and perhaps also in human vanity and weakness. It must not be inferred, however, that these institutions are altogether foolish; far from it. While at times they may appear to be so, and even appear to be harmful in their activities, an unbiased examination of these organizations will show that, for many men, they are helpful and stimulating if only for social purposes.

The criteria of selection of membership in these varied and many-sided societies are usually such qualities as personality, religion, political belief, church affiliations, or, more simply, personal agreeableness. Mental ability and personal accomplishment are usually not important factors, though wealth may be and often is a prime requisite. But for each organization once these criteria are established, they are usually scrupulously observed, and only the "elect" are admitted to the charmed circle.

Societies that are organized to promote pure or applied science rest upon very different grounds. Admission to these organizations does not depend upon political or religious belief, nationality, or race. *There is no single basis upon which all men can so readily affiliate as the pursuit of scientific truth.* Here the criterion of admission is *scientific attainment.* In more recent years, as the importance of these scientific societies has grown, a more careful scrutiny has been given to the personal character of applicants, particularly as regards professional ethics; but even with these modifying influences the catholicity of these scientific bodies remains remarkably broad.

Every man should belong to the scientific society that represents his profession or calling. There is no other way in which he can so readily evaluate his own abilities as in contrasting them with those of his fellow-workers. Furthermore there is no similar means by which he may evaluate his profession among similar activities and thus obtain a clear prospective of what it means to his country. In the congress of his fellow-scientists and those affiliated with them and in the literature of his profession are found those contacts and influences that make for greater personal attainment and broader appreciation of the work of the world.

To the young engineer and scientist these remarks are particularly applicable. Membership in one of these societies gives him access to the best literature of his profession, namely, its publications. At the gatherings of his chosen society he will find the men who are making the history of his calling and from whom he can draw inspiration and help. And in the society of his fellow-workers he will find that satisfaction he so greatly desires, namely, to "belong." In these societies he will find opportunity for promoting his profession and making it more useful for humanity. And should these associations and the work he may do for his society bring him personal promotion in the society itself, he will find no honor that may come to him quite so sweet as the approbation of his own fellow-craftsmen.

[1] Dean, College of Engineering, Cornell University.

The Code of Ethics

By JOHN LYLE HARRINGTON,[1] KANSAS CITY, MO.

ENGINEERING, as an organized profession, is comparatively young; hence its place is not clearly established in the popular mind and it has only the slender beginnings of a legal position. It is divided into many branches, each in part organized as a separate group, while large numbers of men of all grades are without legal status or professional association, therefore it has not established a code for the government of its ethical practice. A brief, fundamental code of ethics has recently been adopted and committees on professional practice have been set up by this and other societies, but it must be satisfactorily administered, materially amplified, well supported by precedent, and generally accepted before it will fully serve the purpose for which it was drawn.

The military, medical, legal, and clerical professions were established early in the history of the race, and their places are fairly fixed in law and in the minds of men. They have traditions and customs of long standing and they have well-recognized codes of ethics and the means for compelling conformity to them. The requirements for admission to practice are clearly established and compliance with them is compulsory.

An attorney found guilty of a major offence may be legally denied the privilege of practicing his profession. Means are provided in his normal environment for bringing charges, determining the degree of guilt, and for inflicting suitable penalties for all material infractions of the code. The other older learned professions have developed similar means for governing their practice and many of the lesser professions or trades have worked out legal or other organized means of compelling adherence to codes or practices established in the interests of themselves and of the public.

The engineer, substantially alone, has insisted upon extreme freedom of action. Only very recently, and then to a trivial extent, has he submitted to legal requirements for admission to the practice of his profession. A few states require registration and impose qualifications varying from a general commendation by two or three references to examinations of moderate severity; but, in general, any one who chooses may practice any branch of engineering. In the public mind an engineer is any one who adopts the title, and small discrimination is made between the man with sufficient strength and intelligence to carry a rod or run a transit and the highly trained engineer who has spent four or more years at one of our higher institutions of learning and then acquired a sound knowledge of a professional work through years of hard and often ill-paid apprenticeship. In the public mind any one who holds public office to which the title of engineer is attached is, per se, highly competent to perform all duties of the office. Because legal requirements are substantially absent, political friends and influence or willingness to comply with the demands of those in political authority, even pride of locality, are often much more potent factors in securing appointment to public engineering office or engagement to do public work than professional experience and ability. Thus men of no professional training have become the engineers for states and municipalities, and even lawyers have been the engineers in charge of large undertakings. The public pays but is commonly none the wiser, and until the engineer is willing to accept and to conform to strict legal requirements for admission to the practice of his profession he must accept responsibility for this lack of consideration for his profession and the consequent injury to the public interest.

The fundamentals of the ethical code of any profession comprise the portions of the general moral code which are applicable to the practice of that profession, supplemented by particular rules conforming to the high sense of honor and propriety which pertain to a learned profession, but the niceties and details of the code are established only after careful consideration and long experience. The code recently adopted by this and other societies is rudimentary. It is a decided step in the right direction, a good beginning, generally acceptable to the profession, and so fundamental that it is satisfactorily applicable to the widely varying conditions of employment on engineering works and construction, and to private parties. It assumes that the accepted rules for the conduct of

[1] Harrington, Howard & Ash.

business are well known to all men. But business rules are often vague and by no means thoroughly established; furthermore, they are frequently beyond the experience of the young man but recently come from school or from purely technical work; therefore it is expected that in time the code will be so amplified that it will meet all needs of the novitiate without being meticulous or petty.

The great difficulty, however, is that the known rules and laws are not obeyed but are evaded and broken. Writing before the time of Christ, Marcus Petruvius Pollio complained bitterly of the unethical practices of the Roman architects of his day, and his complaints are so pertinent to the present time that they might have been written yesterday. Neither human nature nor the fundamental ideas of ethics nor the too common disregard of them has changed materially in two thousand years. Established and generally accepted provisions for its administration are quite as essential as a widely drawn code. At present the national societies have committees on professional practice, but they labor under several serious disadvantages. Their authority is limited to that of the society, which is material but not vital; their members may be distant from each other and unable to confer readily; they are voluntary bodies and cannot conveniently visit the scene of action and cannot spare time for investigation of more than most important cases, while written submission of charges and evidence and rebuttal are usually tedious, except in very simple cases; the members of the committee will commonly be strangers to both the offending and the aggrieved parties, hence confidence is difficult to establish. These conditions render effective complaint so difficult that the aggrieved party will commonly suffer the injustice rather than present his case, and the offender will rely upon this fact for his protection. It appears imperative to the effective administration of a code of ethics that means be developed for full consideration of cases in the environment of the interested parties.

Fortunately the development of a code of high character is far less dependent upon means for administering it in case of infraction than upon the fundamental moral training of the members of the profession. It is true that upon entering the profession the young engineer has small knowledge of business and professional laws and customs, and that he must acquire knowledge by slow and sometimes painful processes. He is human and subject to all the conflicting impulses and motives of humanity; he is more than normally ambitious or he would have not trained himself for this arduous profession; and pride of knowledge and the high assurance of youth are normally his part, while patience is rarely an outstanding characteristic. But if his training has been sound he will fully appreciate the facts that success attends industry and that, rightly, advancement always lags a little behind the conditions that merit it; that employees' and employers' interests are identical; that his responsibility is coextensive with his duties and that true initiative, rightly applied, is always highly rewarded. It is extremely easy to believe that a fellow-employee has received favor through influence or other unfair means, and to let envy have its disastrous sway; to justify indolence or negligence by belief in inadequate compensation; to look without instead of within for the source of all difficulties and disappointments; but of all the cankerous retardents envy is the most prolific, not only among the younger members but throughout the profession. It leads to many practices which can never bear other than evil fruit; to unfairness in strife for advancement; to questionable methods in the struggle for employment or for business; and it causes those who give it sway to be shunned by potential friend as well as by foe. When occupying the mind it leaves little opportunity for sound development. It destroys the harmony and cordial relations which should exist among the members of the profession, and its greatest harm is to those who indulge in it. Self-interest and lack of courage to face consequences often lead to actions manifestly forbidden by every rule of fairness, and sometimes immediate benefits seem to make unfair means profitable, but smallness and envy never have even this excuse.

If the profession becomes legally responsible as are the medical and legal professions, if the various branches of the profession can harmonize their views with regard to ethical matters, and if local tribunals can be so developed that the injured party may bring the offender immediately to book at the scene of the offence, we may expect full development and effective application of a satisfactory code of professional ethics.

But for the present, at least, the profession must rely chiefly upon the sound moral fiber of its membership. All who have been trained to American ideas of fairness and to the Christian ideas of right and wrong can, by very moderate deliberation, determine the right course in any given case. Neither the nice arguments of the lawyer nor the precise distinctions of the philosopher are required to establish the right. The Ten Commandments are still the fundamental law and all men know them. We need only the courage and the honesty to obey.

The Future of Engineering

IN every field of engineering, and especially with regard to electrical engineering, every development has become the nucleus from which a number of other developments have sprung and each of these has again provided a starting point for further lines of progress. In the case of electrical engineering an enormously wide field has been developed within a century and each year the horizon is widening and the volume of possible new developments proportionately increasing. Future progress will probably be in the following directions:

1 Achievement of greater economy in the direct uses of fuel
2 Greater efficiency of all the apparatus employed in extracting and applying energy from fuel or water or other sources
3 Greater application of energy in electrical form to the amenities of life
4 Improvements in material.

During the past generation nearly all engineering progress has been in the direction of new apparatus and not in the application of new principles. All existing practice is based on the long-known physical laws. It may be anticipated that the newest knowledge of physics will be put to practical application, and because of the greater facilities now available for industrial research it is to be expected that the time lag between the discovery and application of new knowledge will be considerably less than was formerly the case.

In the future the greatest economic advances in engineering will probably come through improvements in materials for the development of which increased knowledge of the constitution and nature of matter is required. All power developments, whether from solar energy, energy of the atom, or combustion of fuel, are all based on the application of the laws of physics and chemistry. The future of engineering requires for its success, therefore, a very close alliance with modern physics, and this can only be brought about by the training of a group of physicist engineers.

The first essential of this training will be that the universities shall instil a thorough knowledge of fundamental principles. Special attention to physics should be given throughout the course. This will be followed by a two years' course of practical training in a works coupled up with or followed by a part-time or full-time course in a university on subjects as and when required by the individual student. To meet this each university should have a post-graduate course specially suited to the local requirements. Students should attend these courses, which might last for a year and take the place of a year of research work now in vogue only after works' experience. On the completion of these courses, which should be restricted to the men who can most benefit by them, and these will be few in number, a higher degree might be awarded.

Throughout all the course of training, whether in school, university, or works, the process of weeding out should be maintained, and only those who can economically profit by advanced training should be permitted to carry through. And it must be remembered at all stages of the training that technical knowledge can never be a substitute for personality, energy, and character.

In conclusion, the engineer of the future should play an ever-increasing part in the public life of the community, and some training to break down his present conservative tendencies is required if he is to acquit himself creditably in this responsibility. (Extract from the Training of the Engineer of the Future, by A. P. M. Fleming, presented before the First World Power Conference, Great Britain.)

Power from the Earth's Heat

By THOMAS T. READ,[1] WASHINGTON, D. C.

The ever-increasing demand for power will at some time in the future lead to a careful study of all of the possible sources of power. At the present time there are several points where, through the bubbling of geysers or hot springs, the heat of the earth is used. However, the earth's temperature increases toward its center. Doctor Reed discusses this in the article on this page. It is followed by a resume of published material about actual installations at favorable places on the earth's surface, and plans proposed by well-known engineers for further development.—Editor.

A SHORT TIME AGO the writer published[2] a brief discussion of the problems involved in cooling the air in mines whose workings had penetrated so deep into the earth that the natural temperature of the surrounding rock mass was above that of the comfort zone for human beings. As a result, he was invited

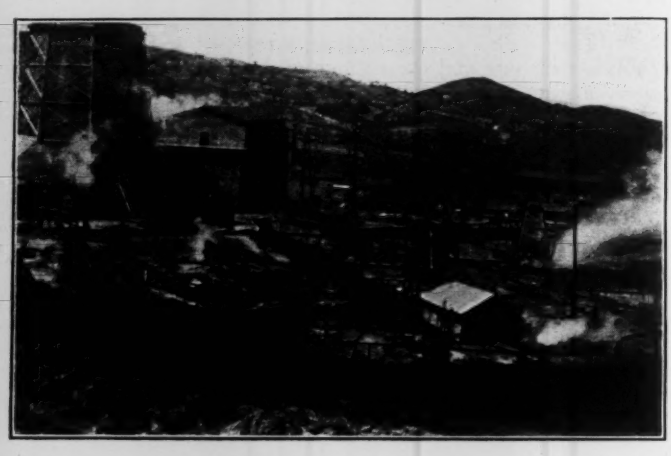

FIG. 1 STEAM WELLS, POWER PLANT, AND COOLING TOWERS AT LARDERELLO, ITALY

to prepare this article. On the face of it, this would seem to be more properly a subject for discussion by a mechanical rather than a mining engineer; but as a matter of fact, the utilization of the heat of the earth as a source of power, in any large degree, undoubtedly lies so far in the future that no one can now foresee what may be the mechanical means of its utilization. Any present discussion of it must be based on fundamental principles rather than on mechanical technology, and it is along these lines that an attempt will be made to discuss the subject.

In the chapter entitled An Inventory of Energy in E. E. Slosson's Chats on Science, the author gives, on page 74, a table of conceivable sources of energy which, with his permission, is reproduced below.

CONCEIVABLE SOURCES OF ENERGY

I Non-Solar
- 1 Tides, lunar
- 2 Internal heat of the earth
- 3 Internal energy of the atom

II Solar
- 1 Direct: solar engines
- 2 Indirect
  - A—Physical
    - (1) Winds: by sails, windmills
    - (2) Waterfalls: by water wheels
    - (3) Solar tides and waves
  - B—Chemical: oxidation of carbon and hydrogen
    - (1) Internal: food
    - (2) External: fuel
      - *a* Gaseous: natural gas
      - *b* Liquid: petroleum, vegetable oils, alcohol
      - *c* Solid
        - (*a*) Coal: ancient, limited
        - (*b*) Wood: modern, continuous.

[1] Safety Service Director, U. S. Bureau of Mines.

[2] Cooling of Mine Air, by T. T. Read and F. C. Houghten. Report of Investigation No. 2554, U. S. Bureau of Mines.

Considering this table, we note that nearly all the energy now being utilized by man falls under II-2-B, the chemical indirect solar. For obvious reasons only a very rough estimate can be made of the horsepower actually used in the United States. If we assume that 7 tons of coal or 1000 gallons of petroleum is a fair figure for the generation of a horsepower-year (24-hour day, 300 days a year) we can use this as a basis of estimate, assuming that half of the bituminous coal, one-third of the anthracite coal, and all the gasoline, gas oil, and fuel oil is used for the production of power. It is a question whether to include the natural gas produced; so little of it is used for power purposes and so much of it is wasted that it has not been included in the table below. As to energy from food, the general assumption is that men work at the rate of 0.1 hp. But in our population of 110,000,000 there are many people who never work at all, or at a much reduced rate; the census figures show only 40 per cent of the population "gainfully employed." The human internal-combustion engine is developing energy even when the individual is not working, and in the absence of any better figure the writer has credited everybody with 0.1 hp. for 8 hours per day. There are no figures at all to go on when we consider the energy domestic animals develop from food. Obviously we cannot include the energy cows, pigs, etc., develop from their food, because it is redeveloped by the human beings who drink milk and eat the flesh of these animals. Horses and mules seem to be the only animals that could be fairly included, and the figure given below for animals cannot be dignified by calling it an estimate; it is a pure guess. Summing up, we have the following approximation of power (in horsepower-years) utilized in the United States in 1923.[1]

FIG. 2 STEAM WELLS AT LARDERELLO AND THE PIPES BRINGING STEAM TO THE POWER PLANT

Coal	33,000,000
Petroleum	19,000,000
Water power	3,000,000
Food, human beings	3,700,000
Food, animals	2,000,000

[1] These figures should not be confused with the capacity of the power plants. The water-power plants in the United States have a capacity of 8,000,000 hp., but as they only work at part capacity they only develop 3,000,000 hp. The capacity of power plants for coal is, similarly, far greater than the total shown.

The only excuse for tabulating such rough approximations (which doubtless will be quoted by people who have no appreciation of the various uncertain factors involved) is to bring out clearly the point that over five-sixths of the power we are now utilizing is derived from sources that are capable of being exhausted, and, in the case of petroleum, are rapidly being exhausted. As the whole tendency of modern civilization is toward the utilization of more power, this combination of increasing demand and diminishing reserve supply forces consideration of the question of what our descendants may do when present sources of supply become inadequate to future needs, since we owe it to them to begin consideration of the problem far enough in advance so that some solution may be available before the problem becomes acute.

In the book referred to above, Dr. Slosson has estimated (p. 72) that the solar energy falling upon a square mile of the earth's surface in this latitude amounts to 700,000 hp. Here is evidently a tremendous source of energy, if means of utilizing it can be found, but that is a problem for the mechanical engineer. The writer knows nothing whatever about the possibilities of utilizing the internal energy of the atom, but he has much more faith in them than in energy from lunar tides, which have been studied enough to indicate that the outlook is decidedly discouraging. This brings us to the consideration of his own topic, the internal heat of the earth.

The first question is as to whether the amount of heat available is sufficient to provide a source of power that would be worth while exploiting. Everyone is familiar with the concept that the earth as a whole is cooling off, but very few people have any idea as to the rate at which it is cooling or of the magnitude of the heat flow. It is not difficult to calculate this in an approximate way if we know the average temperature of the earth's surface, the average temperature of a point in the interior, and the distance between these points, and then substitute in the formula

$$W = \frac{K(T_1 - T_2)}{d}$$

This gives the rate of heat flow per unit of surface and corresponds to a rate of 88 hp. per square mile if we assume that the mean

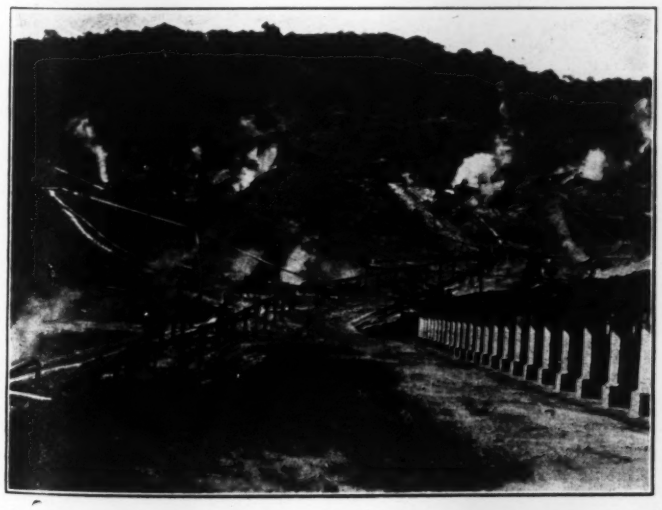

FIG. 3 STEAM WELLS AND BORIC ACID SPRINGS, WITH CONNECTING PIPING AND EVAPORATING SHEDS TO RIGHT

annual temperature of that square mile is 55 deg. fahr. (which corresponds to Washington, D. C.) and that the temperature at a depth of 15,000 ft. is 155 deg. fahr.

The mean annual temperature at Washington is, of course, known to us from the records of the Weather Bureau, but the temperature of 155 deg. fahr. at a depth of 15,000 ft. is derived from assuming a rate of increase of 1 deg. fahr., for each 150 ft. of depth. The U. S. Geological Survey records for the copper mines of Lake Superior indicate a rate of 1 deg. fahr. for each 117 ft., the rate in the Kolar gold field of India seems to be 1 deg. fahr. for 130 ft., the rate in Brazil seems to be 1 deg. fahr. per 165 ft. and 1 deg. fahr. in 245 ft. appears to be the rate in the deep mines of South Africa. As the deepest of these mines (the one in Brazil) is only 6726 ft. in depth, the figure used probably errs on the side of indicating a more rapid rate of increase than actually exists. The large number of well records given in Bulletin No. 701 of the U. S. Geological Survey, entitled Geothermal Data of the United States, would indicate a more rapid rate of increase than this.

Evidently the total quantity of energy available is hardly large enough to be worth considering in comparison with the direct solar energy. The next question is whether it is practicable to

FIG. 4 CASTELMORO (STEAM PIPES FROM THE STEAM WELLS AND HEADER IN CENTER OF PICTURE; LARGE PIPE TO THE EVAPORATING SHEDS, HEATING EVAPORATING PANS)

utilize it. At this point some one will probably interrupt with the remark that it is being utilized. At Larderello, in Italy, a total of 7500 kw. is being developed from steam which issues from the ground in that volcanic region, while near Healdsburg, Sonoma County, California, a somewhat similar project is in coure of development. On the face of it, this would look like conclusive evidence that it can be done, and so it can—in quite exceptional cases like these. Such places where natural steam issues from the ground are local hot spots on the earth's surface. They correspond to a microscopic percentage of the total surface, and most of them are in places where no one has any use for the power that might be produced from them.

The cause of certain places in the earth's crust being hotter than others is a problem in geology and geophysics, and it is generally agreed that the source of the heat is something other than the average condition presupposed above. It was for this reason that the well temperatures were rejected as a basis of estimate of the average rate of increase in depth, and the rates observed in a few deep (and dry) mines used instead.

Exceptional hot spots on the earth's surface, usually in volcanic regions, can be, and even already are, used as a source of power. In these cases steam at reasonably high temperatures and pressures comes to the earth's surface. Usually it cannot be directly used in steam engines because it contains considerable quantities of fixed, non-condensable gases, but it can be used as a source of heat for boilers that generate ordinary steam. Here nature has solved the problem of getting the heat to the surface of the earth. But when we turn our attention to the heat which can reasonably be assumed to exist everywhere at depths of five or six miles below the surface, we regretfully have to conclude that it is extremely improbable that it will ever be possible to get it up to the surface, where it can be used, without losing so much of it on the way that it will not be profitable to get our power in that way unless sources of heat have become so hard to obtain as to necessitate very large capital and operating expenditures to get it.

In conclusion, the writer would make the point that what we have to have for the development of power is a temperature difference; $T_1 - T_2$ is the all-important part of the equation. It is therefore just as logical to look for cold spots on the earth's surface as it is to look for hot spots. Lake Superior is such a cold

spot, and that enormous body of water has a year-round temperature not much above the freezing point. If we could use that as the T_2, there are various other possibilities as to T_1, such as the St. Louis River, which runs into the lake at Duluth and has a summer temperature considerably above it. Best of all, if we could only devise some way of getting the Gulf Stream and polar ice cap near enough together, what a wonderful power project might be promoted!

Recent Developments in the Utilization of the Earth's Heat

IN VIEW of the interesting character of the question of possible utilization of internal heat of the earth for practical purposes, the following information has been compiled from various sources.

The interest in the subject of the structure of the earth's crust and possible utilization of the heat that may be in the interior of the globe is quite old. As far back as the middle of the eighteenth century, a famous member of the Berlin Academy, Pierre de Maupertuis, conceived the idea of digging a shaft to the center of the earth with a view of learning what there was in it. The idea was, of course, far in advance of the time, and Voltaire, who was at that time fighting Maupertuis for the favor of the king of Prussia, attacked the famous geologist in a satirical pamphlet which made him the object of laughter in Europe, and, in fact, drove him to his grave.

There have been numerous inventors since that time—the Patent Office is full of the products of their ingenuity—who have devised variously impractical means for utilizing the internal heat of the earth, but it is only quite lately that serious efforts have been made to turn to commercial use at least some of it in places where conditions are particularly favorable.

In January, 1920, Sir Chas. A. Parsons, famous as the inventor of the Parsons turbine, discussed this subject in an address before the Royal Institution in London in which he proposed, among other things, to sink a shaft to a depth of 12 miles, with a view of utilizing the temperatures and pressures due to a hydraulic head of that magnitude combined with the temperature prevailing at the various stages of such a shaft.

Utilizing Natural Steam at Larderello, Italy

The most ambitious practical attempt to utilize the internal heat of the earth has been accomplished at Larderello, in Tuscany, Italy. There under natural conditions steam finds its way through crevices in the soil and sometimes issues at the bottom of small craters filled with water which is kept at boiling point by the steam, but more often as jets of steam or boiling water direct from the earth. These small craters are termed locally "lagoni," while the springs which give only steam are called "soffioni." Besides steam these springs emit a certain percentage of gases, chiefly carbon dioxide, nitrogen, and hydrogen sulphide, together with a certain quantity of helium. Boric acid is also found in the water resulting from the condensation of the steam, although it is not quite clear how it gets into the steam.

The depths of the steam wells range from 60 m. to 120 m. (157 ft. to 354 ft.) and in some instances even 150 m. (592 ft.). The pressure of the steam varies but does not exceed 3 atmos. effective, the mean pressure with maximum output being about 1 atmos. effective.

The idea of utilizing the natural steam springs of Larderello did not become effective until 1897, when the steam therefrom was employed as a means of heating water in a small boiler, the pure steam thus produced being used for driving a steam engine. In 1905 and 1906 experiments were made with a larger boiler and engine which proved to be very satisfactory. In 1912 a 250-kw. turbo-generator was put in. It was originally intended to work the turbine with natural steam but this idea was abandoned and the use of intermediate boilers was decided on instead, adopting the natural steam as a means of heating the water generating the working steam. One reason for this was the doubt as to the manner in which the blades of the turbine might be affected by the gases contained in the natural steam, and another was the difficulty of obtaining sufficient vacuum in the condenser on account of the large amount of non-condensable gases which the natural steam contained. This plant was put in operation in 1913 and the results were so satisfactory that the company decided to erect a plant with three units of 2500 kw. each.

The first unit was not completed until 1916. The boilers, or more correctly speaking, the evaporators, consist of a number of aluminum tubes contained in a shell of sheet iron. The natural steam circulates outside the tubes, while pure steam is generated inside the tubes on the principle of the ordinary water-tube boiler. Aluminum was adopted for the water tubes instead of iron and steel, because the sulphuric acid contained in the natural steam would form a layer of sulphide of iron on the exterior surface of the tubes, thereby lowering the coefficient of heat transmission.

The steam being generated by the evaporators at a pressure of 0.5 atmos. effective, a certain allowance is made for loss of pressure in the steam supply pipes, so that 0.25 atmos. effective is the pressure regarded as available at the admission valves of the turbines.

Steam consumption being about 14 kg. per net kilowatt-hour, over 35,000 kg. of steam pass into each turbine per hour, and the admission valve is made of ample dimensions for the purpose of dealing with such large amounts of low-pressure steam. Each turbine itself is really composed of two turbines, the inlet for the steam being at the center. This device has the advantage of eliminating any longitudinal thrust, besides reducing the diameter of the turbine wheels. The turbines are all of the reaction or Parsons type. Seven stages of expansion are allowed on each side of the rotor, the first five being fitted with brass blades and the remaining two with 5 per cent nickel-steel blades.

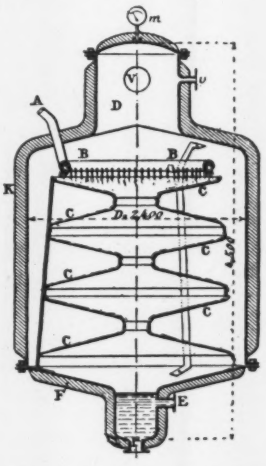

FIG. 5 CAUFOURIER SELF-VAPORIZER FOR GENERATION OF STEAM FROM WATER TEMPERATURES OF 50 TO 75 DEG. CENT.

Another unit of 2500 kw. was installed recently and experiments are in progress for utilizing the natural steam directly in the turbines. This idea as stated above was abandoned in the case of the Larderello plant, but has been taken up again in another of the company's works, namely, at Lago. In that locality a large quantity of natural steam is available and the quantity of gas very much less than in the steam at Larderello. Of course, the air pumps on the condenser would have to be larger than those used in ordinary steam practice, but it is expected that the consumption of power from this source will be amply compensated by the increase of efficiency due to the elimination of the evaporators. Figs. 1 to 4 illustrate some of the features of the Larderello plant.

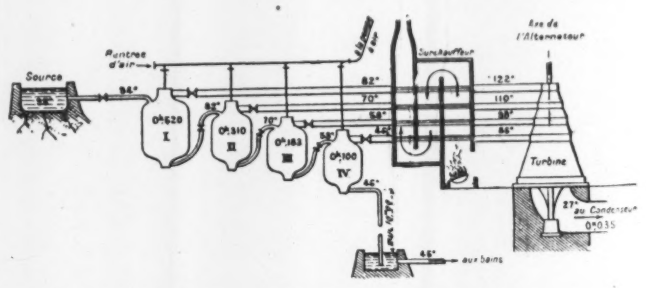

FIG. 6 PROPOSED SCHEME OF INSTALLATION FOR POWER GENERATION FROM NATURAL SOURCES OF HOT WATER

Experimental Work in France

An experiment in a somewhat different direction is under way in France, where a good deal of work has been done with the idea of power generation from natural sources of hot water. In several instances special self-vaporizers have been installed with a view to increasing the volume of steam for medicinal purposes. Of these

may be mentioned particularly the vaporigene of Dr. Lajaunie as used at Aix-les-Thermes, which is built somewhat like an alcohol still. In this apparatus the mixture of gas and vapor generated in the upper part is taken up by a suction pump and sent through tubes surrounded by hot water coming from the ground, the heat of the latter vaporizing the droplets of water carried off with the steam and raising the temperature of the mixture.

For large outputs P. Caufourier suggests a generator built roughly as shown in Fig. 5. The outer casing may be made either of steel or of copper, according to the character of the salts and gases present in the water. In fact, as the pressure is low and the temperature not in excess of 212 deg. fahr., in some cases the casing may be made of concrete provided the water is of such a character that it does not affect the latter materially. This casing is vertical, cylindrical, and surmounted by a dome D, wherein are located the steam outlet V and the vacuum-pump outlet v. The entire structure should be protected by a good heat insulator K. The water admitted through A flows over a perforated sheet B on to a series of dished annular plates C, alternately inclined first toward the center and then toward the periphery, and provided with flanges partly to make the structure more rigid and partly to guide the flow of water. The entire assembly of plates C is rigidly attached to the bottom F, which is made demountable for purposes of periodic cleaning of the surfaces and the bottom. The solid deposits are removed by taking out the plates C, while the mud that accumulates in the lower part of the apparatus may be blown out at P. The cold water is removed through E and may either let out entirely or passed on to the next boiler having a lower pressure of evaporation.

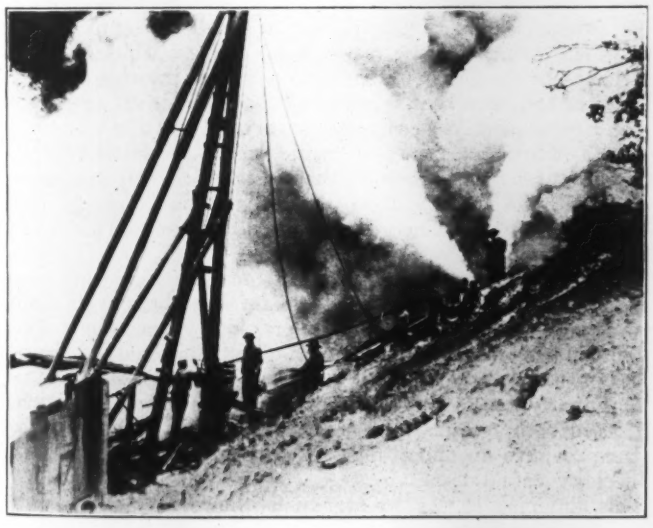

FIG. 7 TWO WELLS 48 FT. APART; STEAM FROM FIRST WELL DRILLED SECOND; SCENE AT SECOND DRILLING IN DEVIL'S CANYON, CAL.

To start the boiler the desired vacuum is created by means of a pump attached to the vacuum outlet v and then hot water is admitted, slowly at first to heat the boiler, and then at the normal rate. Steam is formed on the sheets of water flowing over the plates C and is given off either at the center or along the periphery. In order to make the flow of steam easier the plates C are smaller at the top and larger at the bottom of the generator.

From the generator (Fig. 6) the steam flows to a superheater (*surchauffeur*) the purpose of which is to dry the steam and raise its temperature from 35 to 40 deg. cent. (95 to 104 deg. fahr.). From the superheater the steam may go either to a series of turbines, or preferably to one low-pressure turbine.

At Devil's Canyon, Sonoma County, California, there are two drilled wells (see Figs. 7 and 8) which deliver steam that is being used in steam engines to generate electric current for light and power. A third well, half a mile distant is now being drilled, and it is expected to supply the town of Healdburgh, lying 23 miles away, with sufficient current for lighting and heating. It is confidently estimated that this well will have a capacity in the neighborhood of 2500 hp.

The subterranean reservoir from which the steam issues is supposed to be ten miles long and half a mile wide. It will be remembered that if the volume of steam be sufficient the pressure need be but little above that of the atmosphere, as a condenser may serve to produce the necessary vacuum to induce an effective pressure of ten pounds or more.

There has also been a recent statement in Danish papers to the effect that a movement is on foot at Reykiavik, Iceland, to utilize the hot water of the numerous geysers in the neighborhood of the town for heating the houses. The plan now under consideration is to convey the hot water to the town, a distance not exceeding three miles, in a large wooden pipe and to distribute it along the few streets of the town by means of branch pipes.

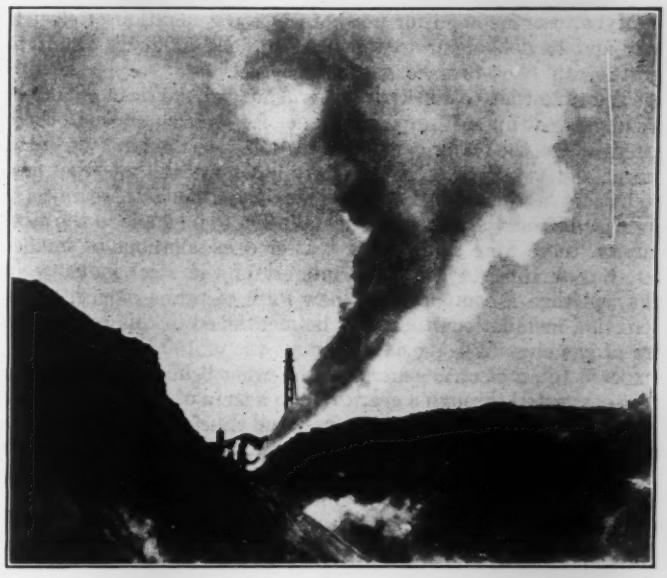

FIG. 8 5-IN. JET OF STEAM OPENED TO ATMOSPHERE; 25-IN. PRESSURE FROM 8-IN. WELL; DEVIL'S CANYON, CAL.

Two papers appearing in the April-May, 1924, issue of *The Journal of Geology* (pp. 177–255, 5 figs.) are of interest because of their bearing on the possibility of utilizing the internal heat of the earth as a future source of power.

One of the papers (by Arthur L. Day and E. T. Allen, Geophysical Laboratory, Carnegie Institution of Washington) deals with the hot springs of the Lassen National Park, California. The majority of these springs are hot, and many are close to the boiling point for the elevation, namely, 91 to 94.5 deg. cent. (196 to 202 deg. fahr.). The source of heat is volcanic, although the authors discuss also radioactivity as a source of heat (this explanation, by the way, is rejected by the authors) and heat developed from chemical processes, the latter being considered to be a minor factor in the heat supply.

The other paper, by Leason H. Adams, Geophysical Laboratory, Carnegie Institution of Washington, deals with the thermal effects accompanying release of pressure.

In a paper presented at the World Power Conference in London, (July, 1924) Prince Piero Ginori Conti gave a brief description of the development at Larderello. The "Solfatara" of Pozzuoli near Naples and the regions round Etna, as well as the islands of Stromboli and Vulcano, he said, are being studied as sources of natural steam where volcanic activity has been at work. A very wide field of research is America. In Alaska, the "Valley of Ten Thousand Smokes" has been very completely explored by the geologists of the U. S. Government. The phenomena are not very different from those of Tuscany, but the volcanic region is far greater in size. In Chile and Bolivia, near the now extinct volcano "Tatio," steam springs of remarkable importance have been found. Those in Chile have been studied with a view to erecting a power plant by one of the engineers of the Larderello Company. Japan is another land where natural steam springs abound. Finally, in New Zealand the Rotorua region is certainly very rich in natural steam and very interesting results could be obtained from the study of that neighborhood.

The Gas Engine in the Steel Industry

The First Four-Cycle Installation—Methods of Governing—Effect of Entering Temperatures of Gas and Air—Piston Troubles and Design—Operating Costs—Engine Tests, Etc.

By A. C. DANKS,[1] CLEVELAND, OHIO

THE first installation of gas engines in the steel industry to attract attention was that at the Buffalo works of the Lackawanna Steel Co. This installation was decided on in 1900 as set forth in a paper[2] read before the Society in 1910 by E. P. Coleman. As pointed out by Mr. Coleman, it was of the two-cycle type, was installed for use both in the generation of electric power and to deliver air to the blast furnaces, and was built to operate with blast-furnace gas as the fuel.

At the time that this installation was made, American engineers were dependent upon European practice for their guidance in these matters and as the major part of the installations then in use abroad were of the two-cycle type it was quite natural that the first installation in this country should be made along these lines.

While this was the first major installation to be made in the steel industry, there were a few other scattered installations of smaller sizes, but tending to show the interest of the steel industry in what was then a comparatively new form of prime mover. Two interesting installations that may be mentioned in this connection were of gas engines using natural gas: one of 150 hp. being belt-connected to an electric generator, the other being of 250 hp. and direct-connected through a gear drive to a train of cold rolls. Both of these engines operated continuously and satisfactorily for a number of years. It is interesting to recall now, that when these installations were proposed by the plant engineers only one of the few companies then building gas engines could be persuaded to figure on a gas engine for this service.

The First Four-Cycle Installation

It was pointed out at this time by the engine builders that if the four-cycle principle were used, with its smaller number of power strokes the crank effort would not be sufficiently uniform to insure satisfactory operation. And as at this time the tandem double-acting engine was in the experimental stage only, and the type generally used was the single-cylinder or tandem opposed cylinder engine, in nearly all cases single-acting, very heavy fly wheels were called for to offset the wide fluctuations in the crank effort.

It was therefore no doubt with some feeling of uncertainty that the engineers of the United States Steel Corporation, when a few years later they became interested in the economies that were possible, decided to make the installation of the first four-cycle type gas engine designed to operate on blast-furnace gas in this country. They accordingly made a purely experimental installation in conjunction with the engine builders for the purpose of determining the characteristics that would enter into the design of larger engines of this type.

This installation was one of exceptional interest and value to all of those interested in the development of the gas engine, as out of it came many valuable lessons as to what could and what could not be done in this line. The story as told in the daily log of this little experimental installation reads in the light of what we now know as a very primitive although interesting tale. There were nevertheless many features of design there established that have withstood the test of the past 19 years.

The cleaning of blast-furnace gas was also in its infancy as far as we in this country were concerned, and practically nothing had been done toward the cleaning of gas for use in hot-blast stoves. So that it was the development of the cleaning of blast-furnace gas necessary for this pioneer engine installation that pointed out the vast possibilities in this respect, now taken advantage of in nearly every steel plant having a blast-furnace installation.

The engine in this small installation was of the horizontal tandem double-acting four-cycle type with cylinders 21¾ in. in diameter and a stroke of 30 in., having a normal speed of 150 r.p.m., and was direct-connected to drive a 250-kw. 280-volt d.c. generator, and so arranged that it was possible to operate either on part of the plant load or on a water rheostat for testing purposes.

As the installation started in November, 1905, and operated until September, 1906, ample opportunity was given to study the characteristics of the blast-furnace-gas-driven engine from all its various angles, and countless indicator cards were taken covering every possible condition of operation. A complete set of indicator cards taken at both low load and full load, when compared with cards from the modern engine of today, show that very little improvement along this particular line has been recorded.

Comparison of Methods of Governing

The most important problem then confronting the gas-engine designer was to decide upon the most suitable of the two forms of governing then in use: namely, that of constant compression in which the air admission was constant and in which the quantity of gas admitted varied, thus giving a variable heat content per cubic foot of cylinder mixture but a constant compression; or that which maintained the ratios of air and gas constant and as determined by the design of the valve gear, thus insuring a cylinder mixture of the same heat value at all loads, but with amounts of gas and consequently a compression varying with the load conditions. The little experimental engine was of the latter type, and as borne out by experience of that installation this system has proved with its various improvements and modifications to be better suited to the changeable conditions of steel mill service and blast-furnace gas.

This opinion is not shared by all of those interested in the gas engine for this service, and while there are several very satisfactory installations using the constant-compression system, the majority of the builders today use the constant-mixture or some combination of the two.

In the early stages of development of the large engine, installations that used both systems were made and it was the author's good fortune to have an opportunity to clarify his own views on this subject by actual tests.

This difference in the two systems is shown very clearly in the series of cards given herewith. Cards from a 42 by 54-in. engine operating at 83½ r.p.m. and direct-connected to a 2000-kw. generator, are shown in Figs. 1 and 2, series *A* being representative cards at full load or 100 per cent rating of the generator, and series *B* at friction or no load.

This engine was operating on the constant-compression principle of governing. It will be noticed that both No. 3 cylinders were not firing and it was also found while taking these cards that this missing was not confined to any one cylinder. It should be noted, however, that at full load the cards were as nearly perfect as is possible to get them, and it was found that the point at which this condition became noticeable was at about ¾ load.

In contrast to this are the series *C* and *D* of Figs. 3 and 4, that were taken from a 40 by 54-in. engine running at a speed of 76 r.p.m., this unit also being a direct-connected set.

The more uniform conditions of the no-load cards, Series *C*, are quite noticeable and there are misfires, although the full-load cards, Series *D*, show practically no difference. The difference in compression pressures in the two systems is plainly seen and easily compared as each similar series was taken with the same spring.

It will be noticed in the power cards in Series *E*, Fig. 5, that were taken at full load, that while the gas analysis was comparatively low the mean effective pressure (m.e.p.) was very good and uniform.

This is also shown in the no-load Series *F* of Fig. 6, where with practically the same gas condition, the m.e.p. for each cylinder

[1] Pres., The Ashmead-Danks Co.

[2] First Large Gas-Engine Installation in American Steel Works, E. P. Coleman. Trans. A.S.M.E., vol. 32, p. 1361.

Contributed by the Oil and Gas Power Division and presented at the Spring Meeting, Cleveland Ohio, May 26 to 29, 1924, of The American Society of Mechanical Engineers, 29 West 39th St., New York. All papers are subject to revision.

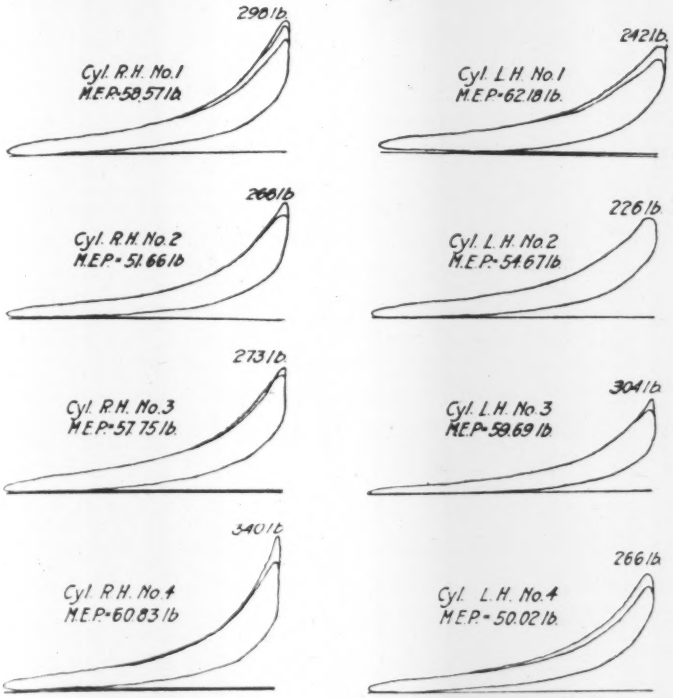

FIG. 1 INDICATOR CARDS FROM A 42 × 54-IN. GAS ENGINE OPERATING AT 83⅓ R.P.M. ON CONSTANT-COMPRESSION PRINCIPLE, AT FULL LOAD (2000 KW.)

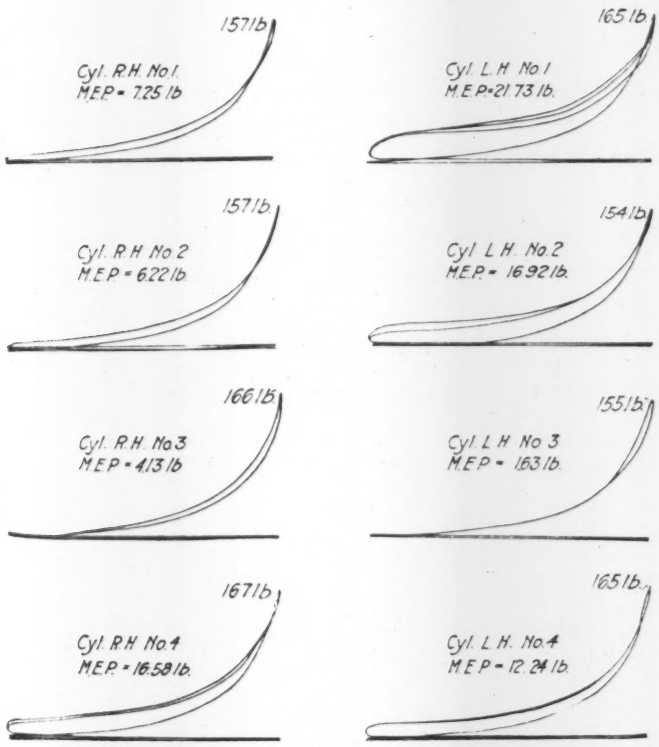

FIG. 2 INDICATOR CARDS FOR ENGINE AS IN FIG. 1 AT FRICTION OR NO LOAD

is very close, which speaks very well for both the condition of adjustment and the method of governing.

COMBINATION SYSTEM OF GOVERNING

The ideal condition to be realized in a gas engine for service on this fuel is to combine both systems of governing as each has its advantage at various loads. This has done much to remove the early feeling of uncertainty that prevailed when by reason of faulty mixtures at times of irregular gas supply from the blast furnaces, back-firing and preignition would occur to an extent that became serious, whether in an electric drive or a blowing unit, at times serious enough to cause the electrical load to be dropped or the blast to be lost or partly reduced on the furnaces. With the gas engine of today, however, many records are available of continuous runs over periods of 90 days and longer, and with entire freedom from trouble.

VALVE GEAR IN RELATION TO GAS ANALYSIS

Another important point in considering systems of governing is the wide variation of the character of the blast-furnace gas. As an illustration the actual analyses given in Table 1 will serve to show what the gas engine may have to handle.

TABLE 1 ANALYSES OF BLAST-FURNACE GAS TAKEN FROM FURNACES ON DIFFERENT KINDS OF IRON

	CO_2	CO	H	N
Bessemer P basic	12.9	25.2	3.7	58.2
Spiegel (20 per cent Mg)	6.5	30.0	3.0	60.5
Ferromanganese (80 per cent Mg)	5.0	34.4	2.7	57.9
Ferrosilicon (10 per cent Si)	3.6	33.0	2.3	61.1

It will be seen from these analyses that the amounts of gas required vary widely. This calls for a very flexible valve gear if

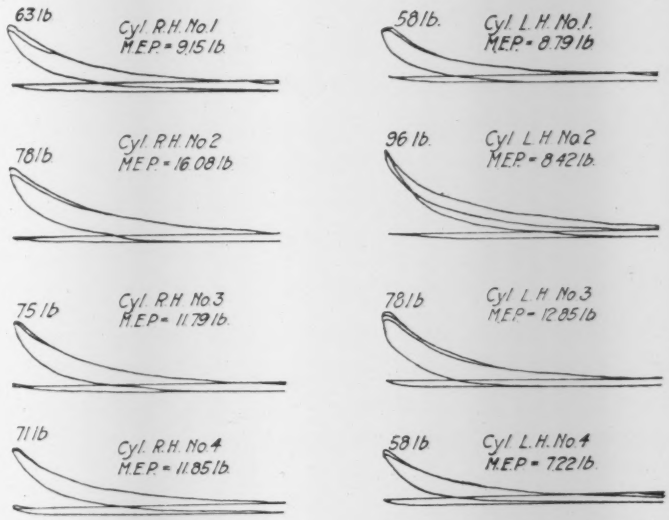

FIG. 3 INDICATOR CARDS FOR A 40 × 54-IN. ENGINE OPERATING AT 76 R.P.M. AT NO LOAD

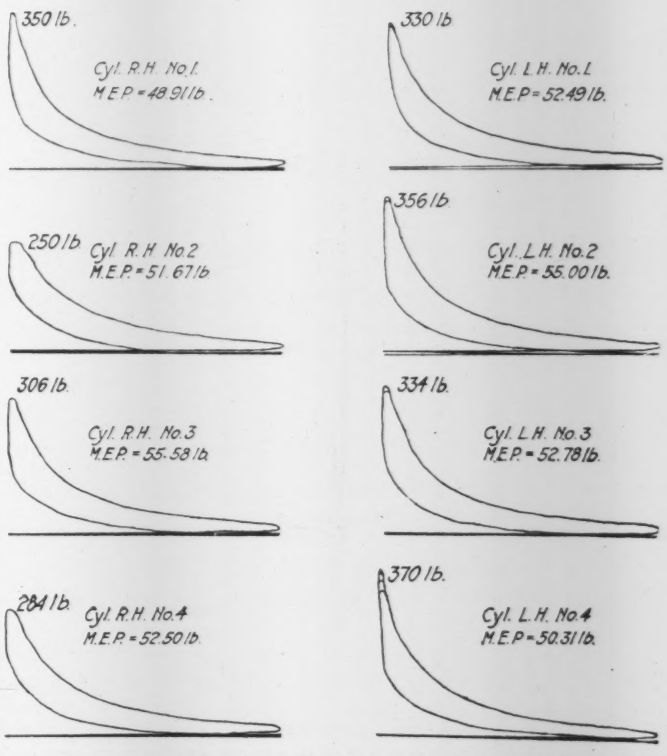

FIG. 4 INDICATOR CARDS FOR ENGINE AS IN FIG. 3 AT FULL LOAD (1500 KW.)

the entire range of gas is to be handled, and while it is true that these changes do not come suddenly, yet it is quite possible that the product of the furnace may change from time to time within the life of the installation, thus calling for an engine that will be able to utilize all the variations of gas produced without introducing the trouble that often follows such a change.

This is not the only cause for requiring flexibility in the valve gear, as changes occur in the same product, due to the various furnace operations.

This is shown very plainly from the following analyses taken while a single furnace, from which the engines were drawing their supply, was passing through the process of casting. These variations are sufficient to set up backfiring and premature firing if the valve gear is not sufficiently flexible to handle them.

	CO	CO_2	H	N
Sample No. 1.....	25.90	12.60	11.80	49.70
Sample No. 2.....	29.60	12.50	12.32	45.58

At this particular time the engines involved slowed down so much from the backfiring that they were taken off the furnace. When the conditions were normal the gas analysis was running around 24.60 CO, 14.50 CO_2, 3.50 H, and 57.40 N, and while exception might be taken to the unusually high hydrogen content in the gas, it can be accounted for by leakage into the furnace through a tuyere or cooler.

It will be seen that the increased heat value to be handled was considerable and had a decided effect on the valve-gear design as the amount of air by volume required for blast-furnace gas is comparatively small, about 75 parts air and 100 parts gas, while with natural gas it reaches a ratio of as high as 10 parts air to 1 part of gas, depending on the composition of the gas. So that the port ratios of this type of engine have less flexibility than with other gases.

The author had this very forcibly brought home to him by having to enlarge the air ports on one engine before it could be successfully operated on gas from a furnace making ferrosilicon iron. In order to determine and fix the actual ratio best suited, a series of cards was taken, and as they illustrate very clearly the importance of the port ratios on the different gas compositions, they are given in Table 2. In considering these figures it should be borne in

TABLE 2 SUMMARY OF CARDS TAKEN WHILE USING FERROSILICON GAS

(Figures given are averages of three cards. Gas analysis: CO, 30.93; CO_2, 5.00; H, 2.43; N, 61.74. Heating value of gas, 116.39 B.t.u. per cu. ft.)

Ratio of Mixture Air, parts	Gas, parts	Ports Air	Ports Gas	Card Data Area	Card Data M. e. p.	Remarks
100	130.5		4 1/4	1.69	72.08	
100	123.0		4	1.63	69.25	
100	115.0		3 3/4	1.62	68.83	
100	107.5		3 1/2	1.61	68.49	
100	100.0		3 1/4	1.51	64.10	
100	92.3		3	1.48	62.80	
100	84.6		2 3/4	1.62	64.50	
100	76.9	3 1/4	2 1/2	1.43	60.75	
100	69.2		2 1/4	1.33	56.50	Start backfiring
100	61.5		2	1.27	54.00	Running good
100	53.7		1 3/4	1.18	50.20	
100	46.2		1 1/2	1.05	44.60	
100	38.5		1 1/4	0.83	35.20	
100	38.5		1	0.85	36.03	

TABLE 3 SUMMARY OF CARDS TAKEN WHILE USING BESSEMER-IRON GAS

(Gas composition: CO_2, 10.40; CO, 23.60; H, 2.80; N, 63.20. Heating value, standard, 92.06 B.t.u.; do, as sampled, 79.17 B.t.u.)

Ratio of Mixture Air, parts	Gas, parts	Ports Air	Ports Gas	Card Data Area	Card Data M. e. p.
100	130.5		4 1/4	1.27	54.56
100	123.0		4	1.35	58.08
100	115.0		3 3/4	1.39	59.84
100	107.5		3 1/2	1.37	58.88
100	100.0		3 1/4	1.40	60.16
100	92.3		3	1.42	61.12
100	84.6		2 3/4	1.40	60.16
100	76.9	3 1/4	2 1/2	1.35	58.08
100	69.2		2 1/4	0.98	42.08
100	61.5		2	0.92	39.52
100	53.7		1 3/4	Stopped burning due to bad mixture	
100	46.2		1 1/2		
100	38.5		1 1/4		
100	38.5		1		

mind that as designed for this engine the air and gas parts had a ratio of 100 parts air to 212 parts gas and were later changed to 100 parts air to 130 parts gas. To determine under actual conditions the proper port ratios, one valve with adjustable ports was built, the control removed from the governing system by placing it on an end cylinder and it was traveled through its entire range and cards taken on both types of gas, although the original change was made to burn ferrosilicon gas.

On trying out the same plan after the engine was again running on to bessemer-iron gas, very different results were obtained as the theoretical air for the gas composition is given as 88.3 cu. ft. gas per 100 cu. ft. air and the best results were obtained at 92.3 cu. ft. gas and 100 cu. ft. air or about 11.7 per cent excess air. At no place during the entire range did backfiring occur as with ferrosilicon gas and the maximum m.e.p. is noticeably lower, being reduced in a different position in each case.

These two tables show clearly the variations that result in port changes with the two gases. One noticeable feature on bessemer-iron gas is that when 100 parts air and 53.7 parts gas was reached, ignition failed, and it is seen that the range of possible port ratio is small. When comparing the bessemer to the ferrosilicon gas, it will also be noticed that the maximum power is reached on

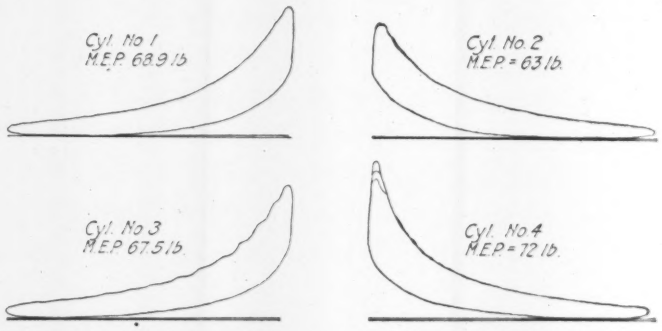

FIG. 5 CARDS OF ENGINE RUNNING AT 150 R.P.M. AT FULL LOAD ON 85 B.T.U. GAS

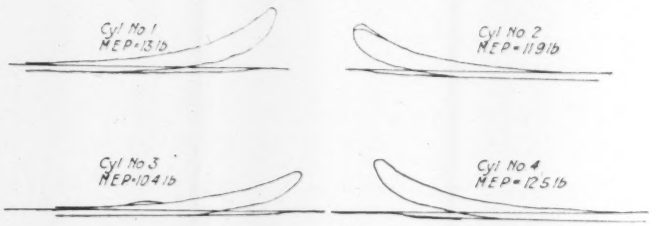

FIG. 6 CARDS OF ENGINE OF FIG. 5 RUNNING AT NO LOAD

bessemer gas with 100 parts air and 92 parts gas, a very nearly equal proportion, while with ferrosilicon the greatest power was with 100 parts air and 130.5 parts gas. But with both gases it will be seen that the range of port ratios is comparatively small.

One other factor that has entered into the operation of the modern gas engine that did not exist in the early installations is the introduction—in fact, we might say the complete adoption—of by-product coke for the blast furnaces. This together with the continually lowering coke rates on the furnaces had had a decided effect on the gas engine and will have a still further influence, depending upon just how far the improvement in blast-furnace practice carries this feature of its operation.

During the early years of gas-engine operation in the steel plants beehive coke was used exclusively, and the coke rates varied from 2300 to 2500 lb. per ton of iron. This gave a heating value of anything from 95 to 110 B.t.u. per cu. ft. and was ideal fuel with the compressions around 160 to 190 lb. that were prevailing at that time. This gas composition and its corresponding heating value have been gradually declining for the two reasons given. This changing tendency of the gas analysis is plainly seen in the curves shown in Fig. 7, where the average monthly gas analyses have been plotted for a number of years. When the loss of yearly averages is followed and the occasional sudden changes due to plant disturbances are considered, it can be realized just what the gas engine has to contend with in the increasing efficiency of blast-furnace operation.

While this loss in the heating value of gas has had a certain effect on the rating of the gas engine for given sizes of cylinders, we are able now to secure cylinders of materially larger diameter than was at first thought feasible, and this in a measure compensates for much of the loss.

The first two engines to be installed following the experimental unit just described were for blowing service and had 38¼-in. gas cylinders, 60-in. air cylinders and a stroke of 54 in., and even with these sizes there were certain misgivings as to the possible outcome. The next unit went a step further with 40¼-in. cylinders with the same stroke but built for 75 r.p.m. as against the slower 60 r.p.m. for the blowing units. This was considered quite a big jump in cylinder sizes.

The successful operation of these three power units made in the year of 1906 and 1907 soon led to larger sizes and higher speed, and we believe 48 in. is considered the standard gas-cylinder diameter by several builders of today.

The compressions carried on the earlier engines have been changed very little and are still held around 200 lb. in some types, while in others there is a tendency to lower this with improved methods of ignition and valve-gear arrangement. It is true, however, that improvements in valve gear, mixing proportions of the gas and air, and improved ignition have made it possible to realize considerably higher m.e.p. than were at first thought possible.

In the original engines referred to the rated loads were figured on a basis of 56 lb. per sq. in. m.e.p., while in practice today many tests are available showing as high as 61 to 65 lb., with the highest m.e.p. on gas from basic and bessemer furnaces as will be shown later in test figures.

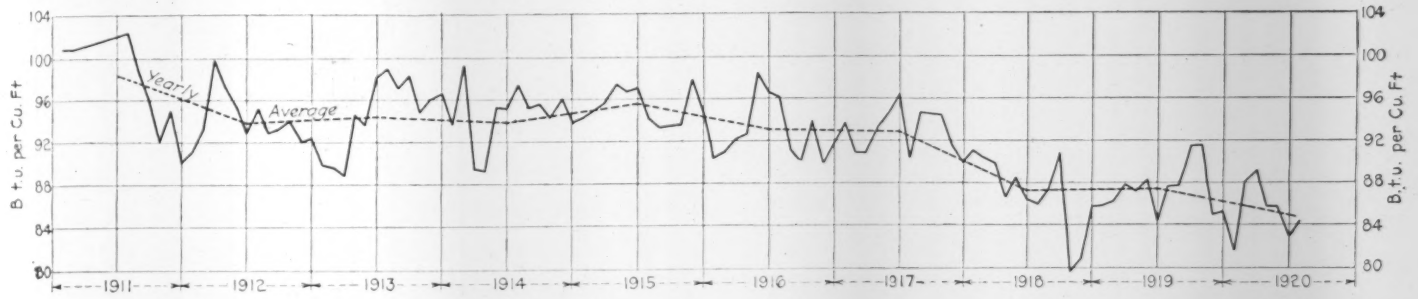

FIG. 7 CURVE SHOWING DECREASE IN B.T.U. PER CU. FT. OF GAS IN LATE YEARS
(From monthly averages of daily gas-washer samples.)

NUMBER AND LOCATION OF IGNITERS

It was early recognized that both the proper number and locations of the igniters had much to do with the m.e.p. developed through more complete combustion and many and various arrangements were tried out to secure the desired results. On the experimental engine referred to the "jump spark" was tried and soon found to be unsatisfactory. This was followed by a magnetically operated igniter to avoid the necessity of a separate shaft for driving this set of igniters, which was usually placed on the opposite side of the engine and not accessible to the drives from the other igniters. This, too, was shortly abandoned for the more substantial mechanical make and break for all igniters with an additional lay shaft, and has become the accepted design for this service.

This variation in card area, power developed, etc. by the various locations of the igniter is shown in Fig. 8, cards 1 to 7, inclusive. It should be mentioned that these are all from the same cylinder and taken with the gas valve blocked so that the same amount of gas entered the cylinder each time, and the variation of area in the card is the result of better ignition alone and not of load change.

TABLE 4 TEST SHOWING EFFECT OF CHANGE OF INLET TEMPERATURE ON THE ENGINE MEAN EFFECTIVE PRESSURES
(L.H., No. 1 cylinder, No. 1 engine)

Date, 1908	8/4	9/23	9/28	9/29	10/3	11/4	11/3
Engine-room temp. deg. fahr.	102.0	83.0	71.0	72.0	70.0	65.0	60.0
Air temperature, deg. fahr.	107.0	90.0	82.0	78.0	74.0	68.0	64.0
Gas temperature, deg. fahr.	104.0	84.0	80.0	75.0	70.0	64.0	60.0
Avg. gas and air temperature, deg. fahr.	105.5	87.0	81.0	76.5	72.0	66.0	62.0
Gas Analyses:							
CO (324.27 B.t.u.)	23.4	26.5	26.2	27.5	25.0	26.0	26.5
CO_2	13.6	10.2	4.9	7.2	11.2	10.7	10.8
O	0.0	0.0	0.2	0.0	0.0	0.0	0.0
H (324.73 B.t.u.)	2.4	2.0	0.0	2.0	1.6	1.1	1.8
N	60.6	61.3	68.7	63.3	62.2	62.2	60.9
Effective heating value, B.t.u.	82.7	92.5	85.0	95.7	86.4	87.8	91.84
M.e.p. (at observed heating value)	44.25	50.52	49.5	48.1	51.0	56.8	55.6
M.e.p. reduced to standard 85 B.t.u.	44.9	48.4	49.5	44.8	50.8	55.7	53.2
R.p.m.	48.0	50.0	50.0	50.0	50.0	50.0	50.0

EFFECT OF ENTERING TEMPERATURES OF GAS AND AIR

One other fact that influences the rating possible, but which is often not appreciated to its fullest extent, is the temperature of the entering gas and air where the installation is located so that these become unusually high in the summer months. To find just what effect this temperature change had on the power delivered by the engine, the author made some interesting observations.

Again an end inlet valve was isolated from the governor control and blocked in a predetermined position and allowed to remain so through the entire seasonal changes in temperature, indicator cards being taken at intervals when the temperature changes were apparent. The results are given in Table 4, from which it will be noticed that the range in m.e.p. varied from 55.6 lb. in cold weather to 44.0 lb., and it will be readily appreciated that this in some instances becomes a very important factor in pulling the load.

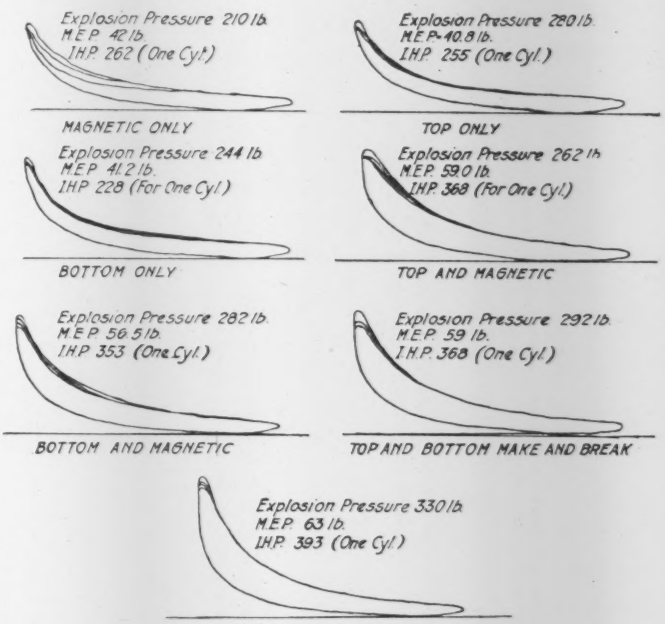

FIG. 8 CARDS SHOWING VARIATION IN POWER DUE TO VARIOUS IGNITER COMBINATIONS AND LOCATIONS
(Taken from 40 by 54-in. electric engine running at 78 r.p.m.)

STUDY OF MECHANICAL RELIABILITY

During the years of early development careful records were made of the delays encountered in gas-engine operation and the causes responsible for these delays, not so much with the intention of making any record runs but to arrive at some conclusion as to the percentage of operation that could really be expected of the units, and if delays occurred, to what parts of the engine were they chargeable.

The results of this study were extremely interesting and they are presented in Table 5 for a number of plants that for obvious reasons have been designated by letters. These records were all made in the same year, and while there may be some question as to the items "Due" and "Not Due" to engines, the total percentage of time in operation for a year of 8760 hr. is interesting, and it will

TABLE 5 ANALYSIS OF DELAYS IN VARIOUS PLANTS

Plants	A[1]	B	C	D	E	F[1]	G[1]	H	I	J
Hours operated	6375	1523	3695	1407	4592	7876	7806	5685	3982	8137
Hours Lost:										
Not due to engine	1683	6689	4080	6550	4363	318	381	246	831	476
Due to engine	702	492	627	804	5	566	573	2075	323	147
Per cent of time in operation	72.8	17.3	42.0	16.1	52.5	89.6	89.0	70.2	77.8	92.7
Plants	K	L	M	N[1]	O[1]	P[1]	Q[1]	R[1]	S	T
Hours operated	7788	5324	5128	5625	3091	5997	8008	7813	6647	3317
Hours Lost:										
Not due to engine	444	2825	3563	3135	1253	2763	375	504	592	2437
Due to engine	1528	611	69	...	...	...	377	443	1521	126
Per cent of time in operation	88.5	60.7	58.3	64.2	71.4	68.5	91.4	89.1	76.0	56.5

[1] Blowing units; all others are electric engines.

be noticed that with very few exceptions the delays were longer on the higher-speed electric engines.

PISTON TROUBLES AND DESIGN

This naturally led to a study of just what the causes of the delays were traceable to, and while local influences were in some cases found responsible, the greater part of the delays were traceable to piston troubles.

To understand this condition it is only necessary to study the development of the large gas-engine piston.

One instance of this is shown in the sections of Figs. 9 to 13. Fig. 9 was the original cast-iron piston used. It soon developed cracks as indicated. This was followed by the piston of Fig. 10

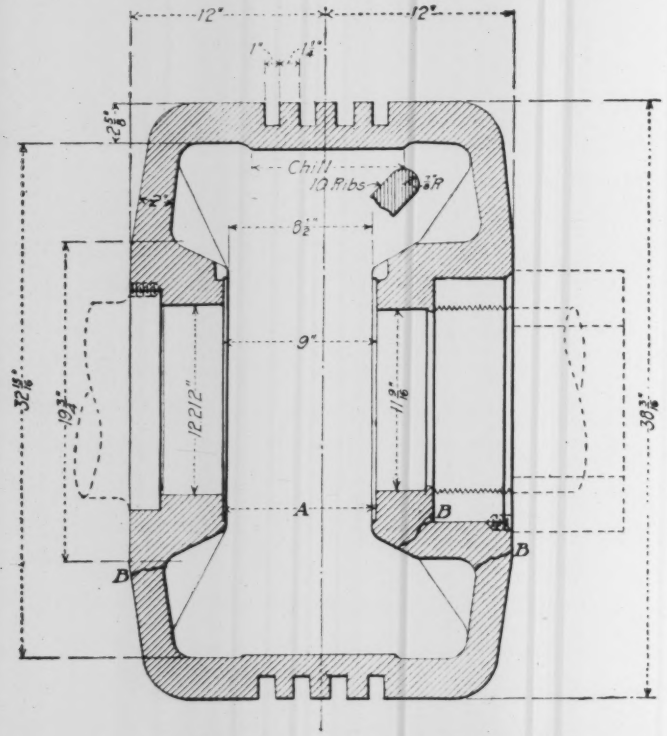

FIG. 9 ORIGINAL CAST-IRON PISTON
(Sectional water-distributing blocks at *A* came loose and piston cracked at points *B*.)

still of cast iron, with cracks resulting in the same location. In Fig. 11 is shown the next attempt, the same piston as that of Fig. 10 made in steel. Trouble with the water-distributing blocks that were clamped by the action of the rod nut against the shoulder on the rod led to the form shown in Fig. 12, and when finally put in shape the piston in Fig. 13 was the result.

The pistons of this last design were in operation for many years and none ever cracked, although a few had to be discarded from "old age," due to the width of the ring grooves reaching a prohibitive figure. The scope of this paper will not allow the author to enter into the many interesting details that accompanied these piston changes, but possibly one of the most notable of these is worthy of attention.

When originally installed the gas engine for this service was provided with water-cooled exhaust valves and piston-rod packing and arrangements were even made to water-cool the inlet valves should it be necessary. This involved endless complication both in construction and maintenance as water leaks were seemingly always present. The first attempt made to run without water either on the rod packing or exhaust valves was not until these trials had been patiently borne for a year or two.

This led to an entire redesign of these various parts, allowing

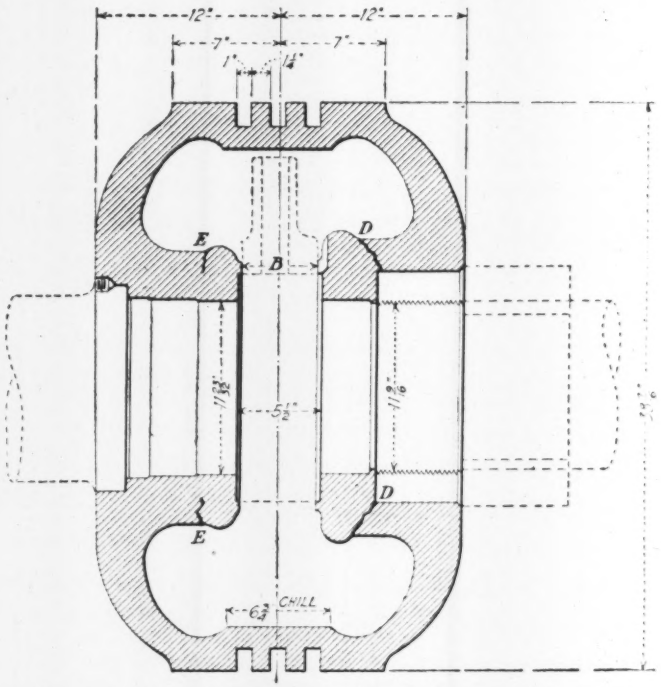

FIG. 10 SECOND CAST-IRON PISTON, DESIGNED TO ASSUME SHAPE OF BALL AS MUCH AS POSSIBLE
(Water-distributing blocks at *B* came loose and cracks developed at *D*. Cracks at *E* form when breaking piston off the rods.)

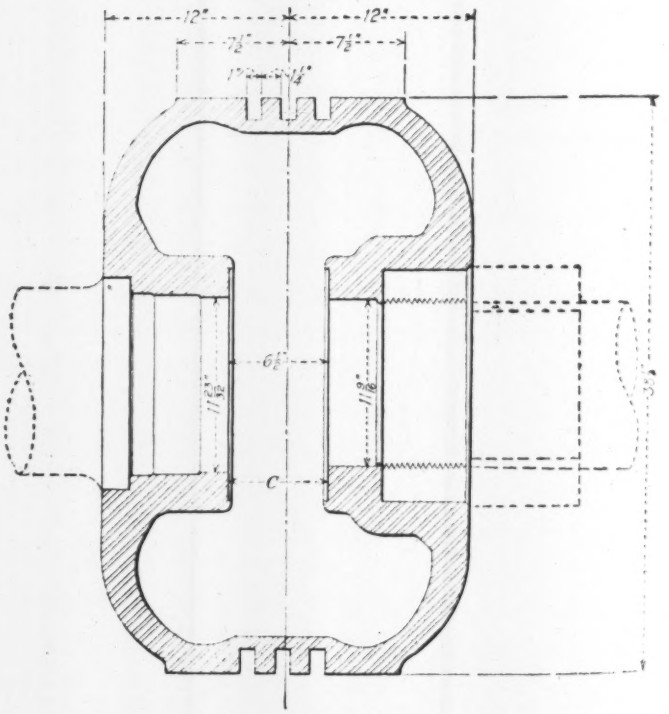

FIG. 11 FIRST FORM OF STEEL PISTON, FOLLOWING LINES OF ORIGINAL CAST-IRON PISTON
(No cracks developed but distributing blocks at *C* came loose.)

of much more simple construction, and consequently reduced the operating troubles materially. Fig. 14 is a cross-section through the valves of a modern gas-engine cylinder that embodies the realization of many of the aims of early designers.

CORROSION DUE TO WATER COOLING

Many interesting studies could be made of the changes in design that have occurred in the various important parts of the steel-plant gas engine, for design was often influenced by local conditions. This was particularly true of the water-cooling equipment as applied to all parts of the engine. Operators on the Great Lakes with clean water can have very little realization of the troubles resulting both directly and indirectly from the supply that many of the inland plants are obliged to use.

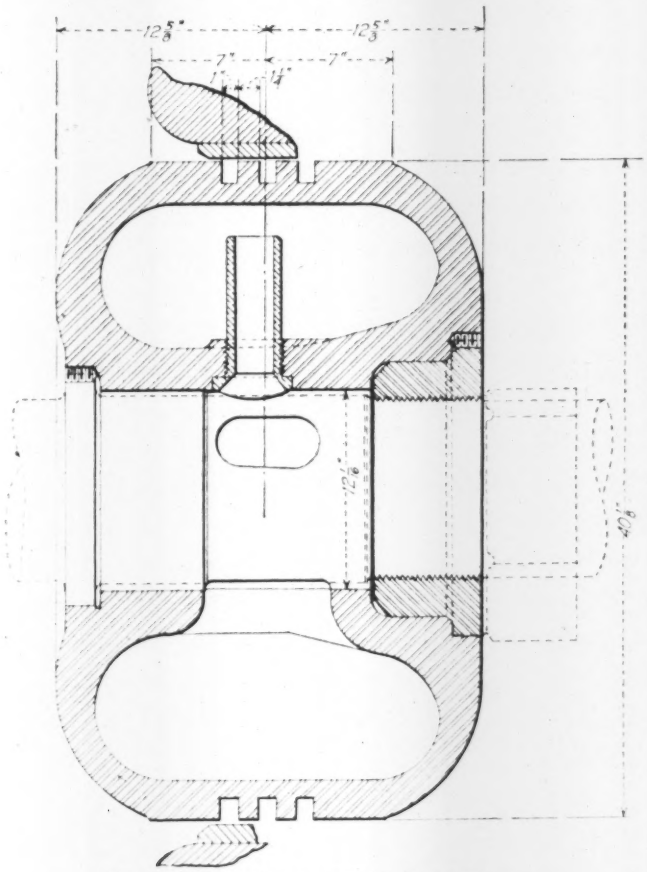

FIG. 12 FINAL FORM OF 40-IN. STEEL PISTON
(No cracks and no inside fittings that could come loose.)

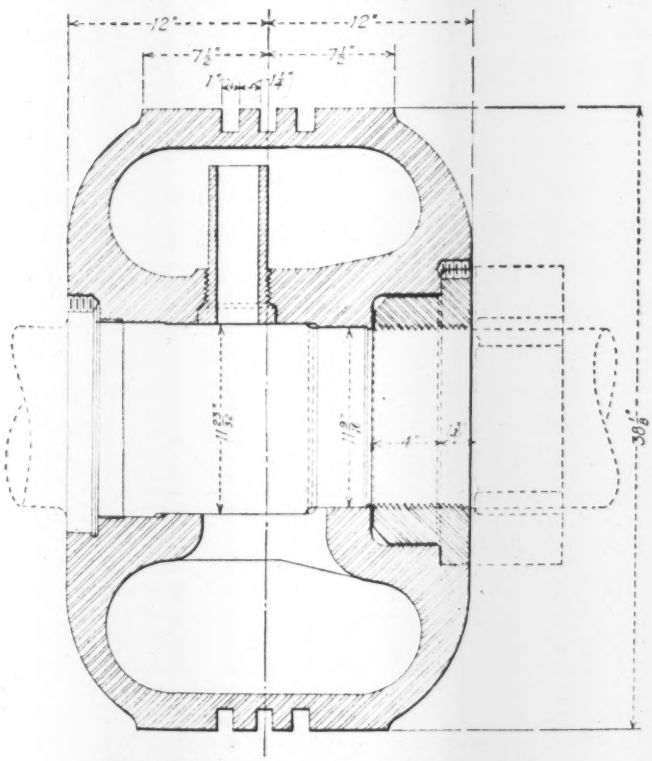

FIG. 13 FINAL FORM OF 38-IN. STEEL PISTON
(No cracks and no inside fittings that could come loose.)

This is particularly true of the Pittsburgh district where much of the water supply comes from the Monongahela River and at certain seasons of the year carries a sulphurous acid content as high as 8 grains per gallon. When the gas engine was first being introduced in that district the provisions for treating the water supply were primitive and it was not unusual to have pipe work last only a few weeks at certain seasons of the year. This eventually led to the use of brass pipe for all water-cooling service.

Had the trouble stopped there the results would not have been so bad, but the author remembers one instance where an entire set of piston rods were completely destroyed in less than a year by being eaten away on the inside so that their strength was reduced to the danger point.

It was noticeable that the attack on cast iron and cast steel, on account of their scale, was much less than on the finished steel

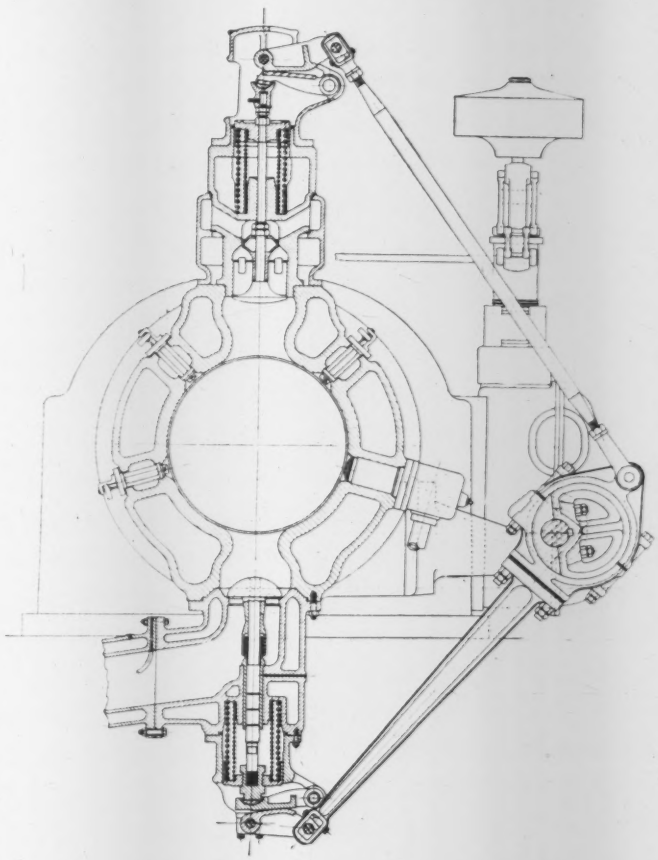

FIG. 14 CROSS-SECTION OF A MODERN GAS-ENGINE CYLINDER

on the rods, and as nearly all piston rods were then being drilled for side water connections it became a serious and important matter to protect them. Many rods were cracked due to weakened sections at these points and it became necessary to inspect all rods closely for indications of cracks.

Considerable difference of opinion existed as to the possible wall thickness of metal that could be tolerated and still leave a sufficiently cool rod surface for safe operation.

This led to a construction shown in Fig. 15, which, while it added considerably to the cost of the rod, entirely eliminated the trouble of internal corrosion; and as the water connections were taken from the ends rather than the sides of the rod it also eliminated the danger of cracks that formerly occurred where these holes were drilled through the rods. The construction consisted in lining the rod entirely with bronze or other acid-resisting material. Where the water passed through the rod under the piston bore the holes were lined with tin. Bronze distributing blocks were used at the center of the rod, and standard brass pipe for lining the bore, with suitable

bronze water fittings on either end for the entering and leaving water.

This particular type of water service to the piston involved the telescoping straight-line sliding plunger. While some types of engine then used and still do use the swinging joint, at the higher speeds this construction is not as desirable as the straight-line telescope.

COSTS OF OPERATION AND CURRENT GENERATION

In pointing out, as the author has, some of the changes that have been found necessary from time to time since the gas engine was first introduced for this service and a few of the difficulties encountered, the impression may be gained that after all the results may not have been worth the effort. To dispel such an idea however, it is only necessary to examine the results that have been obtained in the past few years and compare them on the only basis that after all counts—that of efficiency, and finally cost of operation.

When the gas engine was being introduced into the steel plants between the years 1907 and 1915, coal could be bought at many of the plants at remarkably low figures, in some cases as low as $1.50 per ton (delivered). This of course varied with geographic location.

Plants in those localities having the lower price of fuel had a much harder time making a showing from a standpoint of cost per unit production than those with the higher fuel costs. This was indirectly shown in the cost of coke used on the blast furnace and the consequent value of the by-product blast-furnace gas that the engines were using, as for comparative purposes this must all be reduced to equivalent value of coal at prevailing prices at the particular plant in question.

At that time, also, there were very few plants where the amount of gas that could be saved by the use of gas engines over the other types of prime movers was an important factor, although this condition is becoming to be more and more evident as the demand for power increases above that actually required at the blast furnaces.

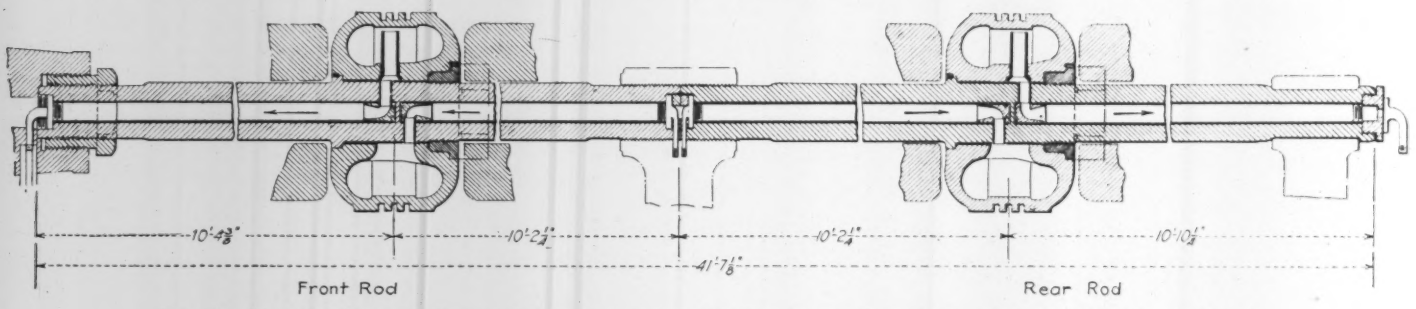

FIG. 15 MODERN ARRANGEMENT OF PISTON RODS ON A GAS ENGINE TO ELIMINATE HOLES THROUGH SIDES OF ROD

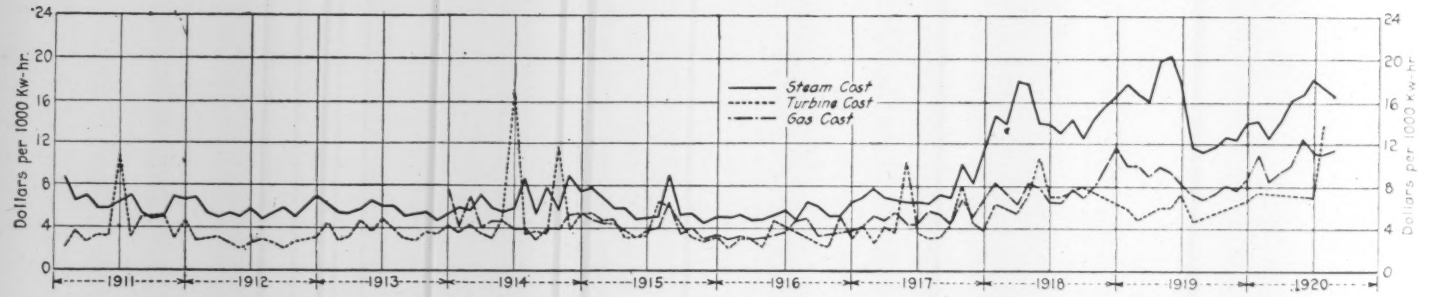

FIG. 16 COSTS IN DOLLARS PER 1000 KW-HR. FOR GAS ENGINES, STEAM ENGINES, AND TURBINES

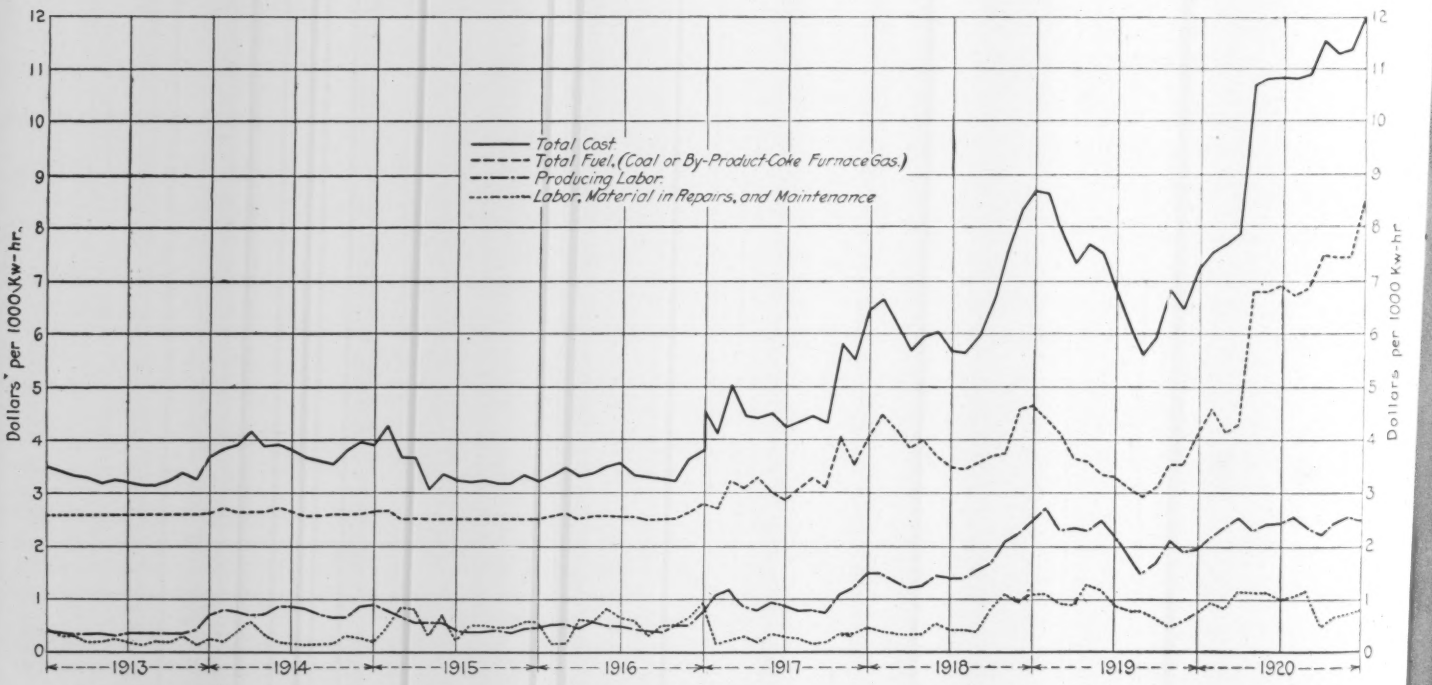

FIG. 17 ANALYSIS OF STEAM COSTS SHOWING RELATION OF FUEL, LABOR, AND REPAIRS TO TOTAL COST IN DOLLARS PER 1000 KW-HR.

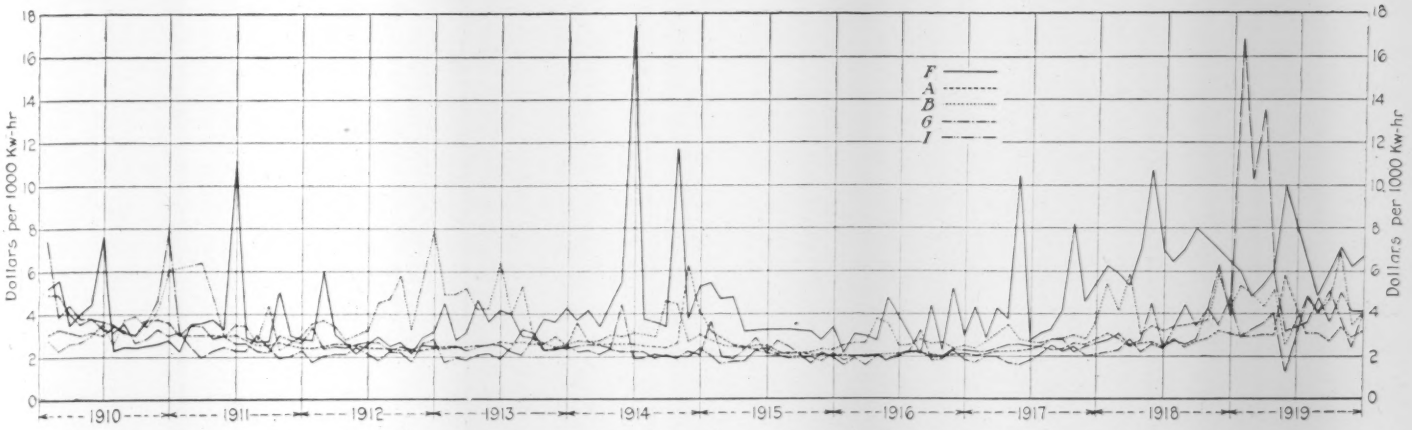

FIG. 18 TOTAL COST OF GAS-ENGINE-GENERATED CURRENT IN FIVE PLANTS IN DOLLARS PER 1000 KW-HR.

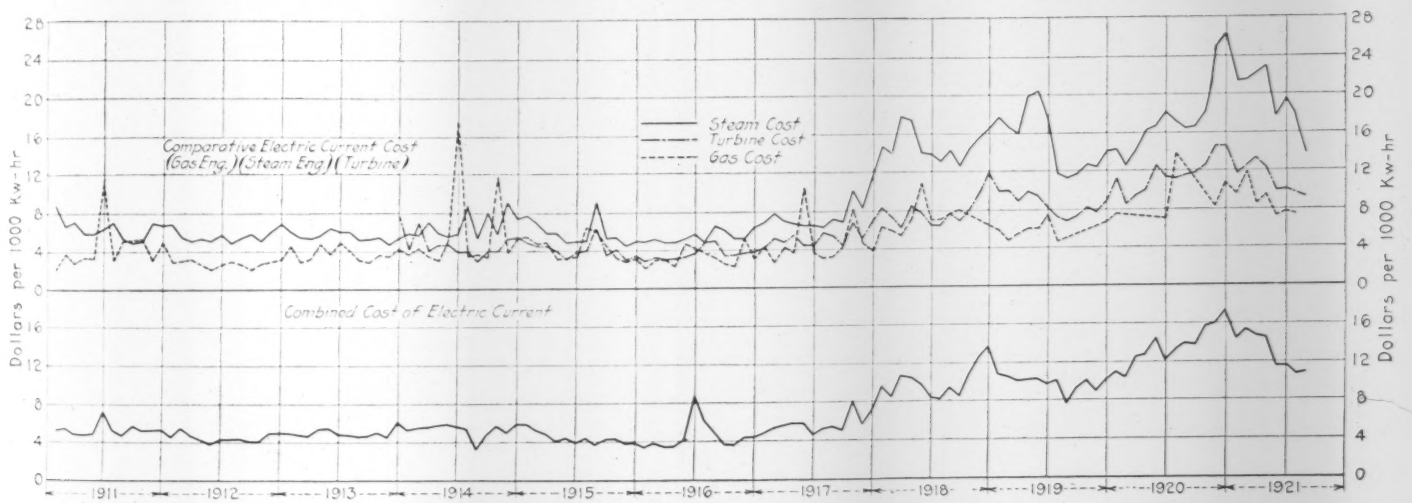

FIG. 19 COMPARATIVE COST FOR GAS-ENGINE-, STEAM-ENGINE-, AND TURBINE-GENERATED CURRENT IN DOLLARS PER 1000 KW-HR.

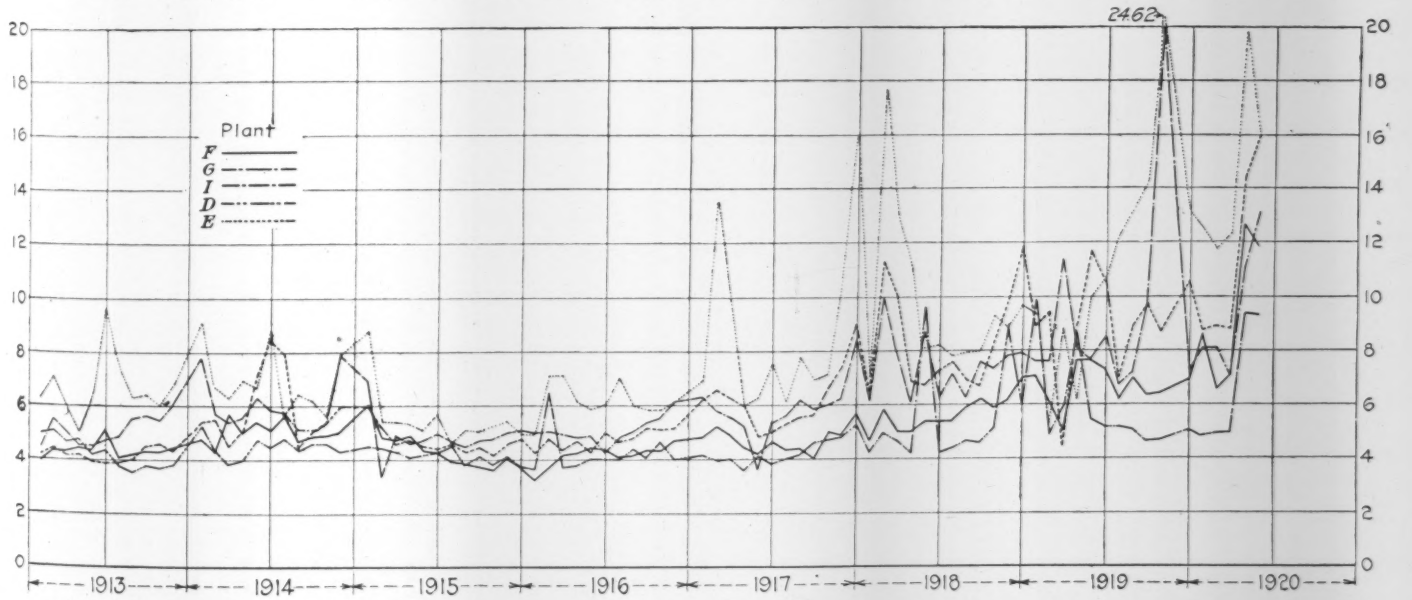

FIG. 20 COMPARATIVE GRAND TOTAL COST OF BLOWING BLAST FURNACES WITH STEAM-ENGINE EQUIPMENT, BASED ON AN ARBITRARY UNIT OF 1,606,140 CU. FT. OF FREE AIR AT 15 LB. GAGE PRESSURE

Roughly speaking gas engines require 125 cu. ft. of blast-furnace gas per i.hp-hr., while 600 cu. ft. are required per boiler hp-hr. The actual number of B.t.u. per 1000 cu. ft. of air blast delivered when comparing a number of plants were as follows, conditions of pressure being the same in both cases:

Steam	Gas
34,900 to 87,000	9,500 to 14,410
39,100 to 88,000	11,180 to 16,100

This shows an advantage for the gas engine that is plainly seen when translated into tons of coal. The gas engine is also able to show an advantage when compared with other types of prime movers in the cost of generating current, mainly through the item of fuel. This is very forcibly brought out in the comparison presented in Table 6, showing the cost of generating electric current in one steel plant by the three common types of prime movers: steam turbines, gas engines, and reciprocating steam engines.

TABLE 6 COST OF GENERATING POWER IN DOLLARS PER 1000 KW-HR.

	Steam engine	Turbine	Gas engine
Producing labor	$ 1.0850	$0.6783	$1.5611
Repairs and maintenance	1.4595	0.4024	2.2363
Miscellaneous supply	0.2624	0.1057	0.3295
Steam or gas	8.9788	6.3825	2.3241
Water	2.5206	0.8875	0.2981
Incidentals	0.1509	0.0236	0.2550
Total cost of production	$14.4572	$8.4800	$7.0041

TABLE 7 ANALYSIS OF COSTS OF GENERATING ELECTRIC CURRENT IN VARIOUS PLANTS

(Costs in dollars per 1000 kw-hr.)

Plant	A	B	C	D	E	F	G	H	I	J
Costs for Year 1911										
Labor	0.420	0.3509	1.846	1.191	0.492	0.445	0.552	0.415	0.661	0.841
Repairs and maintenance	0.3046	1.262	0.675	1.645	0.804	0.885	0.393	0.649	0.598	0.376
Lubricants	0.1000	0.122	1.302	0.298	0.114	0.109	0.088	0.603	0.128	0.141
Total exclusive of fuel	1.035	1.954	4.048	3.333	1.588	1.849	1.256	1.272	1.687	1.813
Fuel cost	1.727	1.756	2.202	1.812	1.289	1.527	0.963	1.318	1.235	2.442
Total cost	2.762	3.711	6.250	5.145	2.877	3.376	2.219	2.590	2.922	4.255
Load factor	55.9	43.7	31.2	50.5	74.0	68.4	67.0	61.7	28.1	42.2
Costs for Year 1914										
Labor	0.400	0.404	0.589	1.160	0.440	0.742	0.533	0.535	0.370	0.581
Repairs and maintenance	0.231	0.575	0.218	0.683	0.436	1.938	0.566	1.055	0.337	0.343
Lubricants	0.105	0.116	0.118	0.410	0.098	0.190	0.140	0.116	0.124	0.142
Total cost exclusive of fuel	0.924	1.242	1.008	2.622	1.083	3.292	1.395	1.849	0.889	1.385
Fuel cost	1.987	1.778	1.819	1.967	1.177	1.820	1.029	1.579	1.386	1.914
Total cost	2.911	3.020	2.827	4.590	2.261	5.113	2.424	3.429	2.275	3.299
Load factor	47.4	64.7	32.6	39.9	64.2	66.9	66.4	54.4	34.4	38.9
Costs for Year 1917										
Labor	0.425	0.485	0.419	1.233	0.583	0.834	0.471	0.691	0.470	0.654
Repairs and maintenance	0.217	0.330	0.356	2.993	0.619	1.213	0.341	0.650	0.625	0.529
Lubricants	0.096	0.107	0.104	0.793	0.117	0.168	0.111	0.138	0.152	0.244
Total cost exclusive of fuel	0.858	1.056	0.920	5.490	1.490	2.532	1.056	1.518	1.300	1.674
Fuel cost	1.53	1.806	1.668	2.204	1.349	1.601	0.9651	1.314	1.189	1.766
Total cost	2.389	2.863	2.589	7.694	2.839	4.134	2.021	2.832	2.489	3.440
Load factor	56.7	70.0	77.2	45.3	75.2	75.6	84.1	73.3	41.8	60.0

TABLE 8 COMPARISON OF STEAM AND GAS BLOWING COSTS IN VARIOUS PLANTS

	Plants									
	A		B		C		D		E	
	Steam	Gas	Steam	Gas	Steam	Gas	Steam	Gas	Steam	Gas
Costs for Year 1914										
Labor	0.5096	0.8645	0.4604	0.5878	0.3806	0.6455	0.5790	0.5421	0.5197	0.4607
Repairs and maintenance	0.3552	0.6508	0.400	0.9932	0.551	1.162	0.3887	0.2710	0.2577	0.2338
Miscellaneous repairs	0.0134	0.0456	0.0137	0.0093	0.0138	0.0129	0.0144	0.0236	0.0703	0.470
Total cost exclusive of fuel	1.032	1.959	0.1983	1.820	1.009	2.259	1.141	1.142	1.016	1.221
Fuel cost	4.054	1.393	4.513	0.7598	4.578	1.771	5.040	1.649	5.845	1.507
Total cost	5.086	4.352	5.712	2.580	5.587	4.030	6.181	2.792	6.862	2.728
1000 B.t.u. per blast unit	67,944	19,096	76,732	12,981	51,760	22,730	56,350	17,836	72,660	18,530
Costs for May, 1917										
Labor	0.4514	0.9871	0.4486	0.6279	0.3235	0.5079	0.4252	0.4748	0.4559	0.5254
Repairs and maintenance	0.3902	0.6564	0.3037	0.5357	0.2862	0.7279	0.2557	0.1425	0.1465	0.1343
Miscellaneous repairs	0.0172	0.0312	0.0099	0.0100	0.0074	0.0120	0.0372	0.0299	0.0507	0.0400
Total cost exclusive of fuel	0.9807	2.042	0.9473	1.405	0.7643	1.525	0.8277	0.8543	0.8344	1.075
Fuel cost	3.214	1.417	3.840	0.8567	4.416	1.525	4.207	1.433	5.512	1.517
Total cost	4.195	3.460	4.787	2.263	5.181	3.050	5.035	2.287	6.346	2.593
1000 B.t.u. per blast unit	56,050	18,630	69,890	15,374	58,390	19,617	50,470	15,594	69,600	19,250
Costs for April, 1920										
Labor	1.143	2.012	1.127	1.586	0.8878	0.7393	6.188	1.211	1.417	2.049
Repairs and maintenance	1.493	0.8023	0.736	1.024	0.584	3.622	1.550	0.9449	0.5011	2.480
Miscellaneous supplies	0.0298	0.0395	0.0250	0.0242	0.046	0.0614	0.0811	0.0486	0.2114	0.3270
Total cost exclusive of fuel	3.013	3.672	2.970	3.193	3.065	5.127	8.571	2.655	2.761	7.924
Fuel cost	9.628	4.182	1.144	2.445	13.813	2.514	13.300	4.125	31.248	5.924
Total cost	12.641	7.854	4.114	5.639	16.879	7.642	21.871	6.781	34.010	13.848
1000 B.t.u. per blast unit	55,673	15,550	60,818	15,660	58,600	19,600	57,967	18,150	139,250	18,540

TABLE 9 GAS-ENGINE TEST

(44 by 60-in. electric unit, constant-compression type.)

Test No.	1	2	3
Duration of test, hr	1¼	2	1½
Per cent of rating	100	100	66⅔
B.t.u. per cu. ft. of gas	90.6	90.6	90.6
Avg. max. explosion pressure, lb. per sq. in.	336	374	246
Avg. m.e.p., lb. per sq. in.	29.72	30.72	21.31
Total hp	4,076	4,087	2,962
Cu. ft. gas per hp-hr	91.8	92	108.9
B.t.u. per hp-hr	8,436	8,451	10,005
Thermal efficiency, per cent	30.17	30.11	25.44

TABLE 10 GAS-ENGINE TEST

(40 by 54-in., 75-r.p.m., direct-connected electric unit operating on blast-furnace gas; constant-compression system of governing.)

Test No.	1	2	3	4	5	6	7
Duration, hr	2	8	8	8	8	3	8
Load, per cent of rating	0	25	50	75	100	125	variable
Avg. compression pressure	60	83	101	140	190	201	.....
Avg. max. explosion pressure	57	137	211	289	353	422	.....
Avg. m.e.p.	11.68	23.84	33.56	46.12	52.44	62.96	.....
Avg. mechanical efficiency	50.16	58.16	73.25	80.18	86.25	94.30	.....
Avg. B.t.u. of gas	90.24	89.15	89.28	87.90	89.98	90.53	90.50
Cu. ft. gas per hp-hr.	172.2	142.9	120.2	115.4	109.3	.....	.....
Gal. cooling water per hp-hr.	42.5	19.5	13.3	11.8	10.8	10.3	17.7
B.t.u. per hp-hr.	15,452	12,746	10,731	10,143	9,835	.....	.....
Thermal efficiency	.....	19.97	23.13	23.59	25.89	25.89	.....

TABLE 11 GAS-ENGINE TEST

(38 by 54-in. engine, 60 r.p.m., 4-cycle, blast-furnace gas constant-mixture type.)

Test No.	1	1	2	3	4
Duration, hr	2½	2	3	1½	2½
R.p.m.	58	58	58	58	56.5
Inlet gas temperature	92	92	86	90	90
Total hp	1,205	1,177	1,155	1,193	1,531
Mechanical efficiency	79.1	81.4	72.5	72.4	77.6
B.t.u. of gas	(Standard)	89.3	92.0	88.1	88.2
Gas per hp-hr., cu. ft.	(Std. 62 & 30)	116.6	118.8	118.7	111.8
B.t.u. per hp-hr.	(Std. gas)	10,423	10,812	10,433	9793
Thermal efficiency	.....	24.4	23.6	24.4	25.9

It will be seen from the figures given in Table 6 that while the repairs and maintenance are high on the gas engine as compared to the steam engine and turbine, the fuel cost is only one-third of that of the turbine. There are times when the cost of gas-generated current rises above that of the other two, but its average from year to year is always below that of the steam engine, and usually below that of the turbine. As the price of coal increases this gap in the costs will become greater and more in favor of the gas engine. This is plainly shown in Fig. 16. From 1914 to practically 1918 the costs were comparatively close together, but with a radical change in the price of coal the difference became very marked.

That this one factor of importance in gas-engine operation is the governing factor is plainly shown in Fig. 17, in which the cost of steam used in turbines and reciprocating engines is analyzed. It will be noticed that its cost follows very closely the cost of fuel and that the other items such as labor, maintenance, etc., in reality have a much smaller effect on the total than is usually thought to be the case.

To show that this condition of cost of current as given for this particular plant is not unusual it will be well to examine the records of several that have come under the author's notice. For obvious reasons, they are referred to by letters, but as the figures are compiled over the same standards and system, the results are comparative.

It will be noticed no doubt that the sum of the separate items plotted in Fig. 17 do not check up with the total. The reason for this is that only the most important items have been given and the discrepancy is due to the omission of miscellaneous small items; the curve of total cost, however, is correct.

To show graphically how these figures hold over a period of time curves for plants A, B, G, F, and I are plotted for a number of years in Fig. 18, and while it will be noticed that occasional peaks are in evidence

TABLE 12 GAS-ENGINE TEST

(21 by 30-in. engine, 160 r.p.m., blast-furnace gas direct-connected to electric generator, constant-mixture type of governor.)

Test No.	1	2	3	4	5	6
Duration, hr	5	5	5	5	5	2
Load per cent of rating	25	50	75	100	variable	no load
Avg. r.p.m.	162.5	161.3	158.9	155.4	160.7	169.7
Avg. maximum explosion pressure	160.5	207.4	283.8	309.6	178.7	88.0
Avg. m.e.p.	23.3	29.4	40.9	47.3	25.5	12.43
Avg. hp.	191.1	243.7	324.3	404.1	253.6	88.73
Avg. mech. efficiency	57.9	73.5	63.2	84.3	72.6	.....
Avg. B.t.u. of gas	98.2	96.1	98.8	97.8	96.6	99.70
Cu. ft. gas per hp-hr.	122.6	118.8	112.5	106.7	120.5	202.2
Gal. cooling water per hp-hr.	35.1	24.8	15.8	18.6	26.0	65.4
B.t.u. per hp-hr.	12,057	11,421	11,116	10,439	11,655	20,148
Thermal efficiency	21.3	22.5	23.1	24.6	22.0	12.7

Dollars per Million Cubic Feet

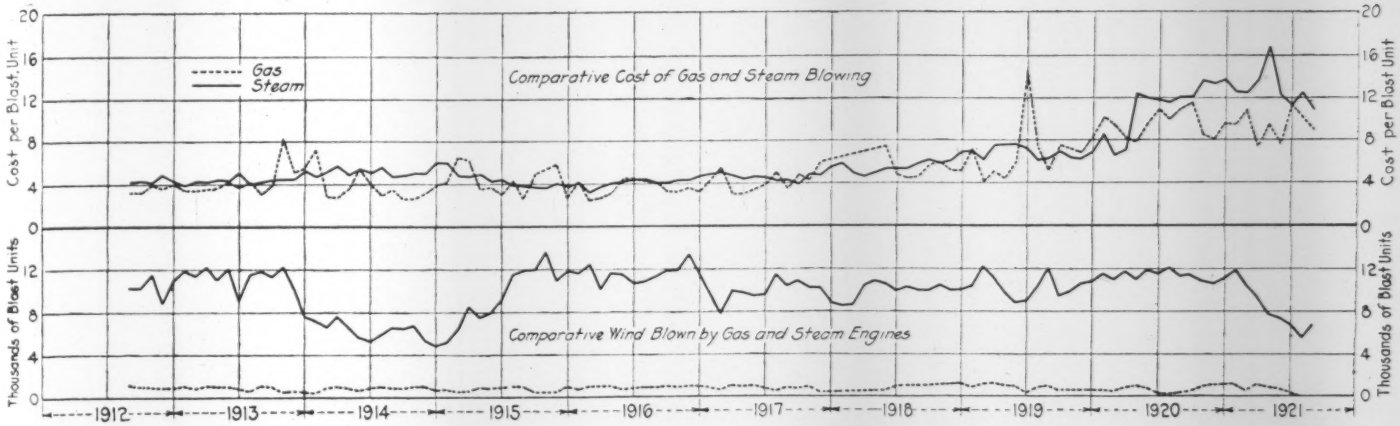

FIG. 21 COMPARATIVE COST OF GAS AND STEAM BLOWING

as the result of some unusual repair, the general trend is very much along the same lines, although the operating conditions of the plants vary considerably due to local conditions.

It will be observed by referring to Table 7, in which the itemized costs are analyzed, that the totals represent a figure very creditable to any existing type of prime mover in any other industry, a fact that is not usually appreciated, and there is no reason why with the freedom from expensive repairs that occurred in some of the earlier engines, the surplus gas in some plants cannot be turned into current and sold to public-service corporations at a figure below their cost of generation. In fact this is actually being done from a certain steam plant. The possibilities for this can be seen to be much greater with gas-engine-generated current as brought out very clearly in Fig. 19.

COSTS IN BLOWING INSTALLATIONS

That similar conditions exist with the gas blowing installations when compared with the steam-driven installations can readily be seen from Table 8. For comparison there have been selected five plants over a wide range of territory, A, B, and C being inland, and D and E being lake plants.

A yearly record is given for the year 1914, just ten years ago, and it is interesting to notice the radical changes in the cost of operation of both steam and gas units, especially that in the fuel cost due to the increased price in coal. It will be noticed also that in no instance is the cost of gas-engine operation more than that of steam-engine operation.

An intermediate position is shown for a month's record of the same plants during the year 1917, and it will be seen that the increased cost of fuel had not been reflected in the operation up to this time.

The unit of comparison used here, it should be stated, is an arbitrary one, established for convenience of comparison of the output of both gas blowing and gas electric engines and being the delivery of 1,606,140 cu. ft. of free air at 15 lb. gage, which is the equivalent of 1000 kw-hr. delivered to the switchboard; so that with conditions otherwise being comparative the efficiencies of the electric engines and steam engines can be compared, at least as far as their operating costs are concerned.

This decided increase in the cost of steam-operated blowing equipment based upon the increase in cost of coal that has occurred within the last few years is very clearly seen by the curves in Fig. 20 for the same five plants.

While it is not possible to show this comparison by diagram over this same period for both the steam and gas plants, the trend is nevertheless seen to be consistent from the curves in Fig. 21, which show a comparison of gas and steam blower costs for plant A. From this it will be seen that at times while the gas-engine cost does run above that of the steam engine on account of some special condition, the line is generally much below. This gap in the costs is becoming wider as the cost of coal advances and the efficiency of the gas engine increases both from a thermal and mechanical standpoint.

In the curves shown in Fig. 22 the cost of the fuel gas entering into the gas-engine operation is shown, and while this too has increased, the change has not been as radical since the cost of gas cleaning has not advanced in keeping with the cost of steam generation; and the change represents only the actual value of the gas on a coal basis, as it will be seen that the two lower lines—those for current cost and repairs and maintenance—have changed but little.

GAS-ENGINE TESTS

In order to present particulars regarding gas-engine efficiencies that have been obtained both from tests and actual operation over different periods of time, results of a number of tests are given in Tables 9, 10, 11, and 12.

When considering the efficiency of any gas-engine installation the first question that is naturally raised is as to the method of measuring the gas, as in handling the large volumes involved in this service the direct-reading meter is out of the question and some form of pitot tube or venturi meter must be resorted to.

When pitot tubes are used their location and operation are of extreme importance as the readings are easily affected by eddy currents set up gas lines containing a number of bends and irregular connections. In short, to secure accurate readings the point of average velocity must be found and this in many instances is hard to do.

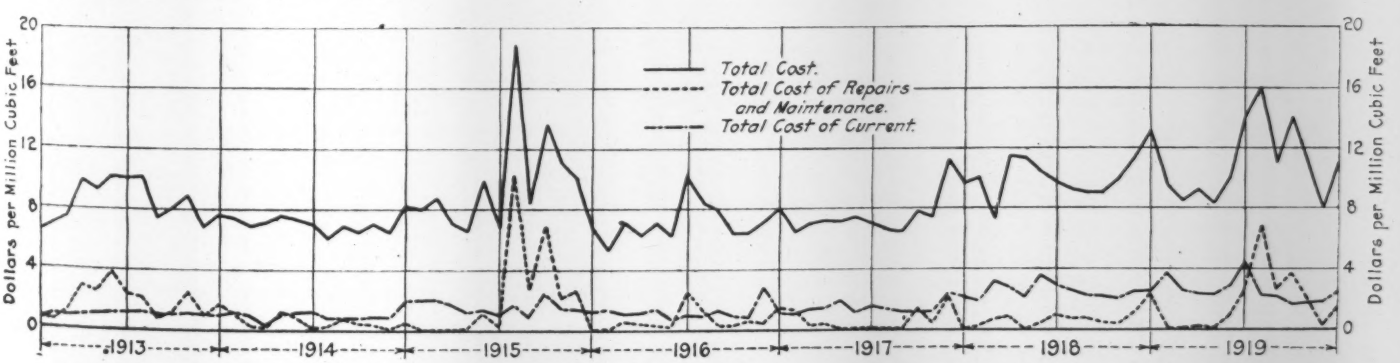

FIG. 22 COMPARISON OF COST OF REPAIRS AND MAINTENANCE AND ELECTRIC CURRENT AGAINST THE TOTAL COST OF PURIFIED GAS IN DOLLARS PER MILLION CU. FT.

Where pulsations enter into the question they doubly complicate it, and the author recalls his first experience with a proportional meter of rather large size that brought home the many factors hinging on the final efficiency of the gas engine as reported by test.

In this particular case it was both surprising and pleasing to find a gas consumption of 6529 B.t.u. per b.hp., and as this represented about 39 per cent normal efficiency, it was naturally concluded that a new record had been established. But this seemed too good to be true, and in calibrating the meter it was discovered that it was entirely impossible to use one of the proportional type where pulsations were present, as was made very evident after it had been replaced around 12,800 B.t.u. per b.hp., or about 20 per cent. Another instance was where a consumption as low as 8000 B.t.u. per b.hp. had been reported and the test published, but upon examination of the installation later it was found that the gas measurements had been made by pitot tube and in locations in the line close to pipe fittings that would render the readings of the tube subject to wide variation.

These instances are mentioned in order to show the importance of first knowing how the gas measurements are made before relying too strongly upon a seemingly exceptional result.

From these tests and tables it will be evident that the gas engine has a place in the steel industry that will increase in importance as the cost of fuel advances, thus automatically increasing the values of blast-furnace gas; for, unlike the by-product gas of the coke oven, it is limited in its range of application to hot-blast stoves, boilers, and gas engines. There is no reason why in plants where this gas supply is in excess of the needs of the stoves and boilers, that the surplus should not be used for the generation of electric power for sale to the public-service companies, and at a figure much below that for which they can make it with any of the existing steam equipment at the prevailing price of coal.

Discussion

F. OTTESEN[1] submitted a written discussion in whichhe said that the piston troubles referred to by the author were past history; all makers now knew how to make good pistons. With cylinders, however, it was different. The cylinder was one of the most vital components of a gas engine and the most difficult to replace. Hence it was of the utmost importance that it be so designed that it could be cast entirely free from internal stresses and that it be given proper care after being put into service. The water jackets should be large and accessible in order to afford easy access for cleaning. As to material, Mr. Ottesen preferred a high grade of air-furnace-melted iron specially annealed and having a tensile strength of 35,000–38,000 lb. per sq. in.

Many gas-cylinder failures were due to the operator's allowing mud and scale-forming substances to build up in the water jacket around the exhaust port, causing hot spots and resulting in premature ignition; or to failing to keep the piston, cylinder heads, valves, and igniter points clean, again resulting in premature ignition. Prolonged premature ignition was the death blow to all gas-engine cylinders, as during its period the explosion pressure rose suddenly 40 to 50 per cent above normal and the temperature correspondingly increased, the result being excessive stresses, the formation of a small crack, and eventual rupture of the walls.

Another cause of premature ignition was the high compression pressure employed in the older engines—about 200 lb. Modern engines used a compression pressure of only 150–165 lb. The average life of a European gas-engine cylinder was about 15 years, and by exercising care in design, reducing the compression pressure, and giving the engine proper attention a similar result should be obtained in America.

W. Trinks[2] wrote that internal corrosion of piston rods had been found to be due to cavitation. With a temporary removal of the pressure, the cooling water would give off gases in the nascent state, in which state they were particularly active. If the pressure came on again suddenly, the cavity would close up instantly resulting in a very high localized pressure which tended to shatter the metal. By employing a pump or other source of high-pressure water and throttling the discharge from the rods sufficiently to form a vacuum in them, they would always be kept full of water, no gases would be given off, and no impact would occur that would shatter the metal. And even with a considerable amount of acidity, no corrosion would result.

The standard method of comparing steam and gas engines employed present prices of coal and coke. A gas engine lasted 20 years, however, so the average price of fuel over that period should be used. The tendency of fuel prices was upward, and in ten years they would be almost doubled. Taking this into account, many more gas engines would be installed than now were being put in.

Dr. Sanford A. Moss[1] said that as nearly as he could make out, Mr. Danks had nowhere taken account of fixed charges in writing his paper. If he were to add the fixed charges to the cost of power in Table 6 he would probably get the turbine cost below the gas-engine cost. It might be possible to use a supercharger in connection with a stationary gas engine, which would reduce the weight and cost per horsepower of output.

G. R. McDermott,[2] referring to Table 5, said that he had recently seen figures in regard to the operation of three gas engines in 1923. One of these ran 94 per cent of the total hours operated, another 88 per cent, and the third, 91 per cent.

C. G. Sprado[3] said that in the engines described in the paper the mean effective pressure was in the neighborhood of 50 lb. The latest engines, however, were running on 80, 90, and sometimes 95 lb. mean effective pressure, which they were able to stand continuously. His company had looked into the matter of supercharging and had found that as long as they could get 90 lb. mean effective pressure with 90-B.t.u. blast-furnace gas, it would not do to load the engines any further on account of heat conditions. They had accordingly dropped the matter until some new angle should present itself.

C. F. Bleyer[4] said that his company had been operating gas engines for some time, and he had yet to find any reason for cleaning them. Cylinder troubles were due mostly to the use of cold water. Waste water from condensers had been used very satisfactorily for cooling purposes. Cylinder inspections, far from being a serious matter, could be made on an engine inside half an hour by using a periscope.

Mr. Danks, in closing, said, in reference to one of the comments made, that he happened to know of one gas engine that had been in operation since 1905 without any change in cylinders and with but one reboring, and from all appearances the cylinders would have a further life of 10 or 12 years, so that 20 years was not too long to allow if the engine were properly handled.

As to Dr. Moss's comment, he would say that in the past, when coal prices were low, it had been difficult to make out a case for the gas engine. But with the price of coal constantly mounting, the ultimate cost of steam-generated power would be such that the favor would all be in the direction of the gas engine.

Further Discussion at Spring Meeting Session on Power Problems of the Steel Industry

IN ADDITION to the preceding paper by Mr. Danks, two other papers were presented at this session, namely, Power Organization in the Steel Industry, by Bryant Bannister and F. M. Van Deventer; and The Generation and Utilization of Steam in the Iron and Steel Industry, by John A. Hunter. Messrs. Bannister and Van Deventer, whose paper appeared in the May issue of MECHANICAL ENGINEERING, showed that the complexity of the problems incident to the operation of the power system of a representative steel works warranted the existence of a highly qualified organization in the nature of a power department, and described such an organization, enumerating the benefits which should result therefrom. Mr. Hunter described the equipment employed for generating and using steam, gave data on fuel costs and the cost of converting the heat of the fuel into steam, indicated present-day

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[2] Asst. Ch. Engr., Illinois Steel Co., South Works, So. Chicago, Ill.
[3] Engr., Allis-Chalmers Mfg. Co., Milwaukee, Wis. Mem. A.S.M.E.
[4] M. M., National Tube Co., Lorain, O. Mem. A.S.M.E.

tendencies in regard to design and size of equipment, described two very recent installations, and showed the probable savings that could be effected if all the steam required in the industry were made and consumed in the most efficient apparatus now in use. His paper was published in last month's issue. An abstract of the discussions of these two papers is given below.

POWER ORGANIZATION IN THE STEEL INDUSTRY

R. J. Horne[1] submitted a written discussion in which he said that the significance of the paper was that the steel industry was now recognizing the economic importance of efficiency and reliability in power generation. Greater returns on the investment might be expected due to the lowering of one of the important items of cost of the finished product. Greater reliability meant greater continuity of plant operation, which also resulted in lower power cost.

The statement was made that a betterment in efficiency resulted in a much greater profit to the user than to the manufacturer of the equipment. The same held true of the improvement of reliability of design. The value of the improvements to the user should and would determine the extent to which these improvements might be carried. That was to say, higher efficiency and reliability meant more expensive construction. On account of the relatively greater importance of fuel economy to the central stations, they would be able to justify a greater expenditure for refinements to that end than could the steel industry. However, reliability of design was of prime importance in both industries, for the products of both were equally affected by shutdowns due to failure of the generating or distributing system.

J. Jay Dunn[2] wrote that the cost of power in its various forms rarely looked formidable in comparison with the total cost. Cost sheets in general did not tell the whole story. For example, insufficient power equipment might keep a plant running in a way most of the time, but there would be delays, the costs of which were considerable and difficult to arrive at. On the other hand, the average mill superintendent would go to unjustifiable lengths to secure freedom from interruptions in operation.

A part of the duties of the proposed central department should be to follow closely the power costs of the various plants and as far as possible familiarize themselves with conditions in the various plants so as to be in position to suggest improvements or changes to the plant manager. This force of engineers should be sufficiently large to permit their acting promptly on particular power problems on the request of the plant manager. It was evident that this central power department could not know local plant conditions fully and this fact should necessarily limit its authority. When improvements were planned, the central department should cooperate with the local-plant power superintendent in the preparation of plans and the selection of equipment, the final decision resting with the plant manager.

J. R. LeVally[3] wrote that without a centralized power department to pass on specifications and equipment the element of friendly rivalry between different plants of a corporation sometimes took the course of keeping a certain type of equipment out of one plant because the local engineer did not want to seem to be copying his brother engineer and desired to show him that he had ideas of his own. Another costly result of individual control was that one plant would go to a considerable expense to arrive at certain conclusions in the use of fuels, and another plant, having the same problem, instead of obtaining the results of the first plant, would practically duplicate the expense and labor to arrive at the same or, as often happened, a different conclusion.

A good illustration of the diversity of opinion in different plants was in the case of superheat. One plant was using 125 deg. at 160 lb. pressure on old equipment with perfect success, another plant in the same organization specified 75 deg. at 160 lb. for the same service, and still another plant claimed that superheat could not be used on old equipment. The steam in these three plants was used in practically the same type of equipment and it was certain that all three of them could not be getting the most out of their steam. A centralized power department could carry on the necessary investigations to determine which of the three was the best procedure both from the operating and the financial standpoint.

C. A. Wendell[1] wrote that, as he understood it, the authors advocated the consolidation of the steam and electrical departments under one head. Such an organization should have the benefit of the intensive study of practical operating conditions, and the new head should possess a thorough business training, a full knowledge of depreciation and plant values, and a recognition of earning capacity and return on investment in order to successfully cope with the various problems.

Mr. Wendell felt that if a head of a new, or rather expanded, department had to be appointed, this should be done on account of the constantly growing importance of the application of economy and efficiency to the use of fuel, either for the making and use of steam or for metallurgical purposes, and he should apply himself and his organization to the study and solving of problems in connection with actual operation wherever fuel in any form was used. Particularly specialized or very technical problems should be left to manufacturers who specialized in various types of apparatus and whose existence depended upon giving the greatest amount of value for the least money investment from the viewpoint of the different operating steel companies.

Peyton R. Hord,[2] in a written discussion, said that it was possible that the plant engineers might raise some objection to the type of organization described by the authors through the belief that their local conditions and handicaps would not be given sufficient consideration, as they doubtless would feel that those who had not had their experience could not appreciate their troubles. From his own observation it would appear that a plant engineer whose chief concern was the machinery involved in the product seldom had sufficient time to devote to power problems to give them the thorough attention they warranted.

A striking example of how this sometimes worked out had been brought to his attention in the Pittsburgh district in the past year. A boiler-room equipment of 4700 rated hp. which was purchased fell so far short of present practice that at a most conservative estimate, based on 100 per cent of rating, it used 20,000 tons of coal more than was necessary in 300 days' operation and at the same time required one man more per shift than would be needed with a proper installation. No doubt, had there existed a properly functioning power organization, this would not have occurred.

L. W. Heller[3] wrote that when the magnitude of the power problem confronting a large steel mill was carefully considered, the need for an organization such as had been outlined was almost self-evident. The question might be raised as to what relationship such a power organization would have with the central-station company operating in the district. The steel mill and the central-station company had a joint problem, for it was impossible to balance the amount of power available from so-called "waste heat" generation and the amount demanded by the steel-mill operations. It was in the proper handling of this unbalance that the central-station and steel-mill engineers would find a common problem worthy of their most careful consideration.

Economically it should be possible to utilize all of the power which could be generated from so-called waste-heat fuel and to obtain all the balance of the power required from the most efficient type of generating equipment available in the district, in most cases that of the central-station company. In general the central-station company, which had no other problem before them than the efficient production of power from primary fuels, would be able to develop larger units and more efficient production than was possible in most steel-mill plants employing the same source of heat. It should then be possible for the central stations and the steel interests to divide the power problem into its elements, each devoting their energy to that portion of the problem with which they were directly and vitally concerned.

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[3] Dist. Mgr., The Superheater Co., Pittsburgh, Pa. Assoc-Mem. A.S.M.E.

[1] M. E., Gary Tube Co., Gary, Ind.
[2] American Engineering Co., Pittsburgh, Pa.
[3] Gen. Supt. of Power Stations, Duquesne Light Co., Pittsburgh, Pa. Assoc-Mem. A.S.M.E.

J. B. Crane[1] wrote that, in the scheme proposed, unless the engineer at headquarters was able to enlist the interest and attention of the manager and others concerned in the new equipment he was quite likely to meet with disappointment over the failure of the apparatus to do what he expected of it. For this reason it seemed to be much better that all such work should be initiated by the manager of the local unit and that the engineer and power superintendent secure his coöperation and interest first and let him make his own recommendations and requisitions. This would keep the responsibility where it belonged and cause the manager to take a personal interest in seeing that the thing worked.

There was another system when the individual units were small that had been worked out successfully in one case. The local managers were all engineers. The manager of the largest unit acted as chief engineer for the organization. The manager of another unit was an electrical engineer, of another a mechanical engineer, and their services were used as required. This replaced an expensive central organization, but, of course, where the individual units were large it would not work, as the manager must be on the job continuously.

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Power engineers in the steel works were required to handle approximately nine kinds of fuel, producing seven kinds of power and four kinds of gas for industrial and metallurgical purposes. When the scope of the work, wide range of fuels, and diversity in kinds of power produced were considered, together with the large amounts of money involved in power production, the need of an ultra high-grade central organization was, he believed, apparent.

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When blast-furnace gas was used as it ought to be and could be, in boilers and stoves, and other power leaks were stopped, the saving would be so great that it would not be surprising if, after producing all the power required in the iron and steel industry itself, there would be such a supply of blast-furnace gas left over that it could be utilized in connection with central electric stations.

T. A. Peebles[5], discussing the paper orally, said that it was sometimes a difficult matter for a manufacturer to get a correct statement of the problem he must meet in, say, a large steel mill or power plant. He believed that one of the very important factors in the rapid development of large central power stations was the close coöperation between the consulting engineers, the engineering organizations of these large central stations, and the manufacturers of equipment, and that the same coöperation covering the variety of power and equipment that went into the steel industry would be highly beneficial, not only to the users of the apparatus but to the manufacturers.

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[4] Asst. Prof. of Commercial Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. Mem. A.S.M.E.
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The Generation and Utilization of Steam in the Iron and Steel Industry

Ernest Pragst[1] contributed a written discussion of Mr. Hunter's paper in which he said that in those plants where blast-furnace gas was available for power generation and much work was performed on the steel between the ingot and finished product, there would rarely, if ever, be an excess of gas over that required for the stoves, for blowing, and for electric power generation. Here it behooved the engineer to seek high station thermal economy to reduce to a minimum the valuable fuel which must be used to compensate for the deficiency in gas. In the case of stations serving a load in excess of 10,000 kw., or perhaps even less, Mr. Pragst believed that the steam conditions at the turbine throttle should not be less than 300 lb. per sq. in. gage pressure with a temperature of 650 deg. fahr. (228 deg. superheat). In the future surface condensers would be used to a greater extent and would be of ample size to secure the maximum vacuum consistent with the temperature of the available cooling water. The more general use of powdered coal in the industry was certain, in furnaces designed for a combination of gas and powdered-coal firing. The use of air preheaters, using steam bled from the turbines, for heating the combustion air before its entrance into the furnace warranted consideration as a simple means of effecting further thermal economies.

G. R. McDermott[2] wrote that he took exception to the author's statement that turbines seemed to have replaced the large gas engines for driving generators. It no doubt would be of interest to state that the Illinois Steel Company, South Works, completed in 1922 a gas-engine station of 13,200 kw. installed capacity. Gas engines for blowing and electric power production predominated in the plants of that company, while steam turbines of moderate size assisted in absorbing the momentary peak loads.

As a result of the recent installation of gas engines, the company had found it necessary to develop uses of blast-furnace gas other than for the production of power in order to stop the bleeding of gas to the atmosphere. They were now using blast-furnace gas in combination with producer gas and tar as fuel for reheating and open-hearth furnaces. The value of blast-furnace gas for this purpose—in their particular case as a reheating-furnace fuel—had increased 50 per cent over that of its coal value for the production of power.

As mentioned by the author, the stack gases from reheating and open-hearth furnaces—and he should also have included gas-engine exhaust gases—were sources of heat for the production of steam by the installation of waste-heat boilers. These waste gases should be fully utilized, not only for the displacement of coal but also blast-furnace gas when used as a steam-producing fuel on account of the latter's further use as a reheating and open-hearth fuel, and also as a fuel for displacing the more valuable coke-oven gas used in connection with reheating and open-hearth furnaces as well as that used for heating the coke ovens themselves. The surplus coke-oven gas would then become available for sale to the public utilities.

W. Trinks[3] wrote that steel plants built twenty to forty years ago contained many overloaded steam engines which used anywhere from 35 to 45 lb. of steam per hp-hr. The boilers maintained good steam pressure and the condensers were large enough, but the large steam consumption caused excessive pressure drop between boiler and engine piston and choked the condenser to such an extent that the effect of the vacuum was scarcely noticeable in the engine. A brief calculation based upon present prices of uniflow engines and disregarding the scrap value of an old engine, showed that in such cases the replacing of the old steam engine by a uni-

(Continued on page 501)

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[2] Asst. Ch. Engr., Illinois Steel Co., South Works, South Chicago, Ill.
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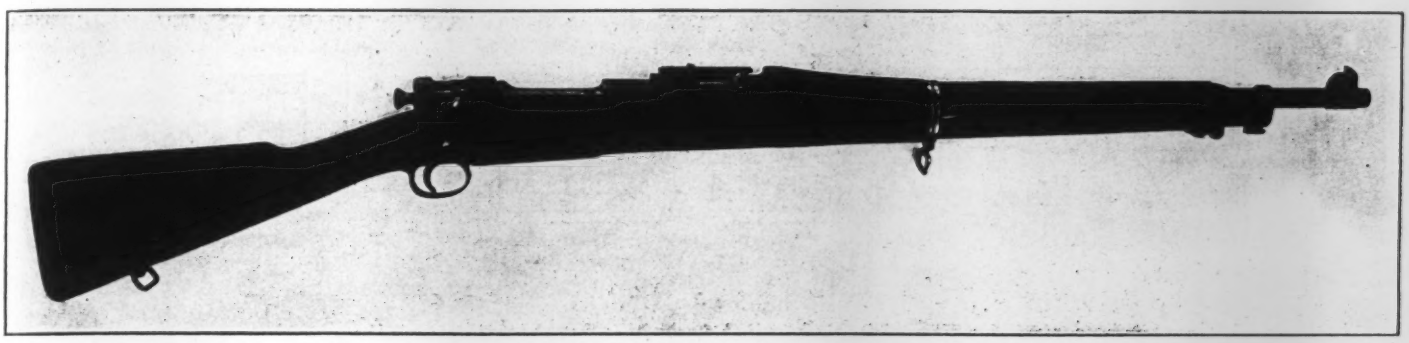

THE SPRINGFIELD RIFLE—MORE PROPERLY CALLED THE UNITED STATES RIFLE, CALIBER .30, MODEL OF 1903

Manufacture of the Bolt of the Springfield Rifle

BY MAJOR EARL McFARLAND,[1] SPRINGFIELD, MASS.

The methods employed in the manufacture of the bolt of the Springfield rifle form an example of the highly specialized use of tools, jigs, fixtures, and gages which is typical of the gun-making industry. The author describes a number of machining operations which are particularly adopted to gun manufacture, but which at the same time may find some application in other lines of production. Particulars of the system of gaging used are also included.

THE Springfield rifle, generally referred to by this name but more properly known as the United States rifle, caliber .30, model of 1903, was adopted for the United States Army as a result of a long series of tests and development work carried out at the Springfield Armory. Prior to this time the Army had been equipped with a .30 caliber rifle known as the Krag-Jorgensen. The new rifle was designed to meet improvements in the art of firearms design and manufacture, and to keep pace with the arms of other nations. The work on the Model of 1903 Rifle was so well performed that this arm still stands as the supreme military weapon of the world. Since starting its manufacture very few changes have been made, other than in the type of sight and bayonet. The operating parts of the rifle have continued with practically no change in design, but of late years the greater requirements for accuracy in target firing and training have imposed very severe restrictions on the latitude allowed in the manufacture of the piece. Each year a limited number of specially selected and targeted rifles are manufactured for use of competing rifle teams at the National Rifle Matches. The rifles selected for this purpose are especially manufactured and gaged by the inspectors in such a way as to reject for this special purpose any components which are not very close on certain specified points.

THE RIFLE COMPONENTS

The principal parts of any rifle are accurately given in the often-used phrase, "lock, stock and barrel." In this sense, however, the lock must be interpreted to mean both the receiver and the bolt. The receiver is the heart, the vital organ, of the arm around which the weapon is built. On the forward end of the receiver is attached the barrel. Within the receiver slides the bolt, which is actually the lock. Under the receiver is fitted the trigger mechanism for firing, and behind the receiver is placed the stock to permit convenient aiming.

The rifle is a unit composed of various components, and each component must be so formed that it bears a correct and very accurate relation to every other component. The various parts are so intimately connected that a modification in one is likely to entail a train of changes in others, even though not in immediate contact with them. These requirements have always called for very fine work in the manufacture of firearms, even before the days of interchangeability. The conception of interchangeable manufacture seems to have originated from the necessity of replacing broken and damaged parts of mutilated rifles on the battlefield. From this origin has grown up the immense field of interchangeable production now followed in all lines of manufacture, but not so much as a means for the replacement of parts as a means of mass production.

The bolt of the Springfield rifle, both as to its importance in the functioning of the arm and as to its interest in manufacture, is a good example of an article or component that presents a real problem in obtaining quantity production with great precision; and the purpose of this paper is to describe in some detail the methods used in the manufacture of this component.

The bolt carries the firing pin and extractor mechanisms, and comes in contact with more components of the rifle than any other part, with the possible exception of the receiver. The smooth and easy working of the rifle depends almost entirely upon the bolt, and satisfactory operation cannot be obtained unless the bolt is accurately machined. The bolt moves backward and forward, and rotates in the well of the receiver; it carries the cartridge into the firing chamber and supports its head when fired. The sleeve screws into the rear end of the bolt. The extractor is attached to it by means of the extractor collar, and the safety lock, cut-off, cocking piece, firing-pin rod, main spring, firing-pin sleeve, and striker are all attached to or come in contact with it. The locking lugs of the bolt when in the closed position are set firmly against corresponding locking surfaces on the receiver. On the accuracy of these surfaces depends the effectiveness of the lock, and on the tolerances given depends the all-important matter of head space. Head space, in turn, controls the satisfactory functioning of the ammunition as it measures the distance between the front supporting shoulder in the chamber and the point of rear support of the cartridge case; if this distance be too great the brass case will be pulled apart by the action of the powder pressure and a broken cartridge case, rendering the rifle inoperative, will result.

The outline, dimensions, and tolerances of the bolt are shown in Fig. 1. Letters indicating the names of certain features are as follows:

A, Handle	*H*, Sleeve-Lock Notch
BB, Locking Lugs	*I*, Firing-Pin Hole
C, Safety Lock	*J*, Cocking Cam
D, Extractor Collar Groove	*K*, Cock Notch
E, Extractor Cam	*L*, Extractor Groove
F, Sleeve Clearance	*M*, Rim
G, Safety-Lock Spindle Notch	

As the problem to be presented is one of manufacture rather than design, it will be presumed that the design as shown is standardized and satisfactory, and that tolerances can be justified; and in fact, even eliminating the question of interchangeability (which however is of material importance in view of the large quantity of rifles in storage), the component parts of the rifle are so connected that even a slight change in one component is almost certain to cause difficulties and unsatisfactory performance on account of its relation with other parts.

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[1] Ordnance Dept., U. S. A. Commanding Officer, Springfield Armory. Mem. A.S.M.E.

Contributed by the Ordnance Division and presented at the Spring Meeting, Cleveland, Ohio, May 26 to 29, 1924, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th St., New York. All papers are subject to revision.

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G. R. McDermott[2] wrote that he took exception to the author's statement that turbines seemed to have replaced the large gas engines for driving generators. It no doubt would be of interest to state that the Illinois Steel Company, South Works, completed in 1922 a gas-engine station of 13,200 kw. installed capacity. Gas engines for blowing and electric power production predominated in the plants of that company, while steam turbines of moderate size assisted in absorbing the momentary peak loads.

As a result of the recent installation of gas engines, the company had found it necessary to develop uses of blast-furnace gas other than for the production of power in order to stop the bleeding of gas to the atmosphere. They were now using blast-furnace gas in combination with producer gas and tar as fuel for reheating and open-hearth furnaces. The value of blast-furnace gas for this purpose—in their particular case as a reheating-furnace fuel—had increased 50 per cent over that of its coal value for the production of power.

As mentioned by the author, the stack gases from reheating and open-hearth furnaces—and he should also have included gas-engine exhaust gases—were sources of heat for the production of steam by the installation of waste-heat boilers. These waste gases should be fully utilized, not only for the displacement of coal but also blast-furnace gas when used as a steam-producing fuel on account of the latter's further use as a reheating and open-hearth fuel, and also as a fuel for displacing the more valuable coke-oven gas used in connection with reheating and open-hearth furnaces as well as that used for heating the coke ovens themselves. The surplus coke-oven gas would then become available for sale to the public utilities.

W. Trinks[3] wrote that steel plants built twenty to forty years ago contained many overloaded steam engines which used anywhere from 35 to 45 lb. of steam per hp-hr. The boilers maintained good steam pressure and the condensers were large enough, but the large steam consumption caused excessive pressure drop between boiler and engine piston and choked the condenser to such an extent that the effect of the vacuum was scarcely noticeable in the engine. A brief calculation based upon present prices of uniflow engines and disregarding the scrap value of an old engine, showed that in such cases the replacing of the old steam engine by a uni-

(*Continued on page 501*)

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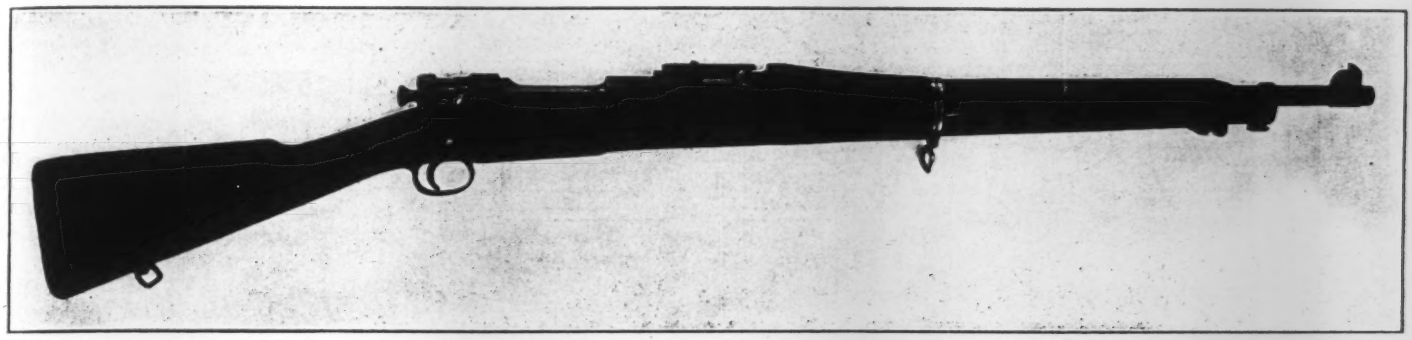
[2] Asst. Ch. Engr., Illinois Steel Co., South Works, South Chicago, Ill.

[3] Prof. M. E., Carnegie Institute of Technology, Pittsburgh, Pa. Mem. A.S.M.E.



THE SPRINGFIELD RIFLE—MORE PROPERLY CALLED THE UNITED STATES RIFLE, CALIBER .30, MODEL OF 1903

Manufacture of the Bolt of the Springfield Rifle

BY MAJOR EARL McFARLAND,[1] SPRINGFIELD, MASS.

The methods employed in the manufacture of the bolt of the Springfield rifle form an example of the highly specialized use of tools, jigs, fixtures, and gages which is typical of the gun-making industry. The author describes a number of machining operations which are particularly adopted to gun manufacture, but which at the same time may find some application in other lines of production. Particulars of the system of gaging used are also included.

THE Springfield rifle, generally referred to by this name but more properly known as the United States rifle, caliber .30, model of 1903, was adopted for the United States Army as a result of a long series of tests and development work carried out at the Springfield Armory. Prior to this time the Army had been equipped with a .30 caliber rifle known as the Krag-Jorgensen. The new rifle was designed to meet improvements in the art of firearms design and manufacture, and to keep pace with the arms of other nations. The work on the Model of 1903 Rifle was so well performed that this arm still stands as the supreme military weapon of the world. Since starting its manufacture very few changes have been made, other than in the type of sight and bayonet. The operating parts of the rifle have continued with practically no change in design, but of late years the greater requirements for accuracy in target firing and training have imposed very severe restrictions on the latitude allowed in the manufacture of the piece. Each year a limited number of specially selected and targeted rifles are manufactured for use of competing rifle teams at the National Rifle Matches. The rifles selected for this purpose are especially manufactured and gaged by the inspectors in such a way as to reject for this special purpose any components which are not very close on certain specified points.

THE RIFLE COMPONENTS

The principal parts of any rifle are accurately given in the often-used phrase, "lock, stock and barrel." In this sense, however, the lock must be interpreted to mean both the receiver and the bolt. The receiver is the heart, the vital organ, of the arm around which the weapon is built. On the forward end of the receiver is attached the barrel. Within the receiver slides the bolt, which is actually the lock. Under the receiver is fitted the trigger mechanism for firing, and behind the receiver is placed the stock to permit convenient aiming.

The rifle is a unit composed of various components, and each component must be so formed that it bears a correct and very accurate relation to every other component. The various parts are so intimately connected that a modification in one is likely to entail a train of changes in others, even though not in immediate contact with them. These requirements have always called for very fine work in the manufacture of firearms, even before the days of interchangeability. The conception of interchangeable manufacture seems to have originated from the necessity of replacing broken and damaged parts of mutilated rifles on the battlefield. From this origin has grown up the immense field of interchangeable production now followed in all lines of manufacture, but not so much as a means for the replacement of parts as a means of mass production.

The bolt of the Springfield rifle, both as to its importance in the functioning of the arm and as to its interest in manufacture, is a good example of an article or component that presents a real problem in obtaining quantity production with great precision; and the purpose of this paper is to describe in some detail the methods used in the manufacture of this component.

The bolt carries the firing pin and extractor mechanisms, and comes in contact with more components of the rifle than any other part, with the possible exception of the receiver. The smooth and easy working of the rifle depends almost entirely upon the bolt, and satisfactory operation cannot be obtained unless the bolt is accurately machined. The bolt moves backward and forward, and rotates in the well of the receiver; it carries the cartridge into the firing chamber and supports its head when fired. The sleeve screws into the rear end of the bolt. The extractor is attached to it by means of the extractor collar, and the safety lock, cut-off, cocking piece, firing-pin rod, main spring, firing-pin sleeve, and striker are all attached to or come in contact with it. The locking lugs of the bolt when in the closed position are set firmly against corresponding locking surfaces on the receiver. On the accuracy of these surfaces depends the effectiveness of the lock, and on the tolerances given depends the all-important matter of head space. Head space, in turn, controls the satisfactory functioning of the ammunition as it measures the distance between the front supporting shoulder in the chamber and the point of rear support of the cartridge case; if this distance be too great the brass case will be pulled apart by the action of the powder pressure and a broken cartridge case, rendering the rifle inoperative, will result.

The outline, dimensions, and tolerances of the bolt are shown in Fig. 1. Letters indicating the names of certain features are as follows:

A, Handle	*H*, Sleeve-Lock Notch
BB, Locking Lugs	*I*, Firing-Pin Hole
C, Safety Lock	*J*, Cocking Cam
D, Extractor Collar Groove	*K*, Cock Notch
E, Extractor Cam	*L*, Extractor Groove
F, Sleeve Clearance	*M*, Rim
G, Safety-Lock Spindle Notch	

As the problem to be presented is one of manufacture rather than design, it will be presumed that the design as shown is standardized and satisfactory, and that tolerances can be justified; and in fact, even eliminating the question of interchangeability (which however is of material importance in view of the large quantity of rifles in storage), the component parts of the rifle are so connected that even a slight change in one component is almost certain to cause difficulties and unsatisfactory performance on account of its relation with other parts.

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[1] Ordnance Dept., U. S. A. Commanding Officer, Springfield Armory. Mem. A.S.M.E.

Contributed by the Ordnance Division and presented at the Spring Meeting, Cleveland, Ohio, May 26 to 29, 1924, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th St., New York. All papers are subject to revision.

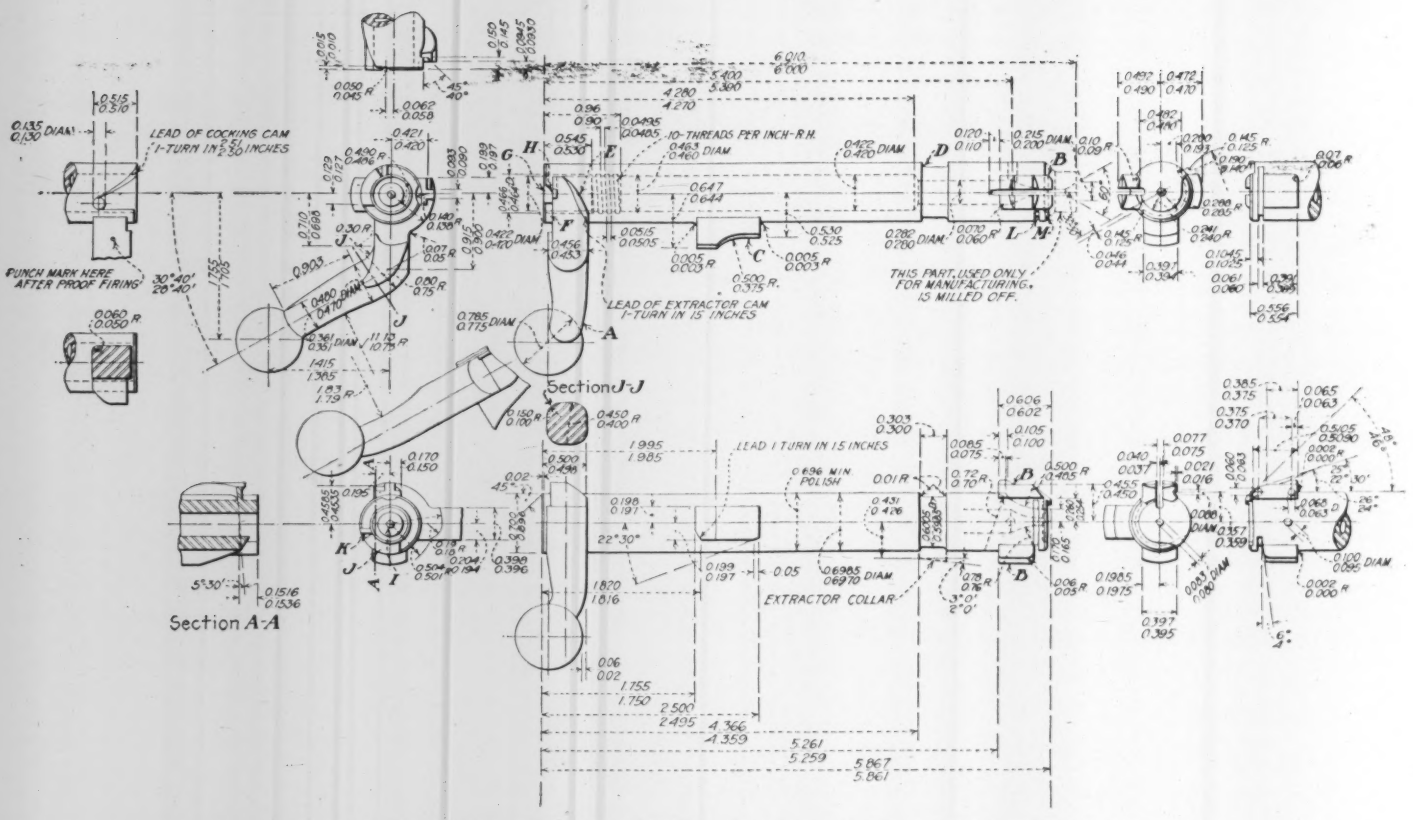
LEAD OF COCKING CAM 1-TURN IN 2.50 INCHES
10-THREADS PER INCH-R.H.
PUNCH MARK HERE AFTER PROOF FIRING
LEAD OF EXTRACTOR CAM 1-TURN IN 15 INCHES
THIS PART USED ONLY FOR MANUFACTURING, IS MILLED OFF.
Section J-J
LEAD 1 TURN IN 15 INCHES
EXTRACTOR COLLAR
Section A-A

Fig. 1 Outline, Dimensions, and Tolerances of the Bolt of the Springfield Rifle

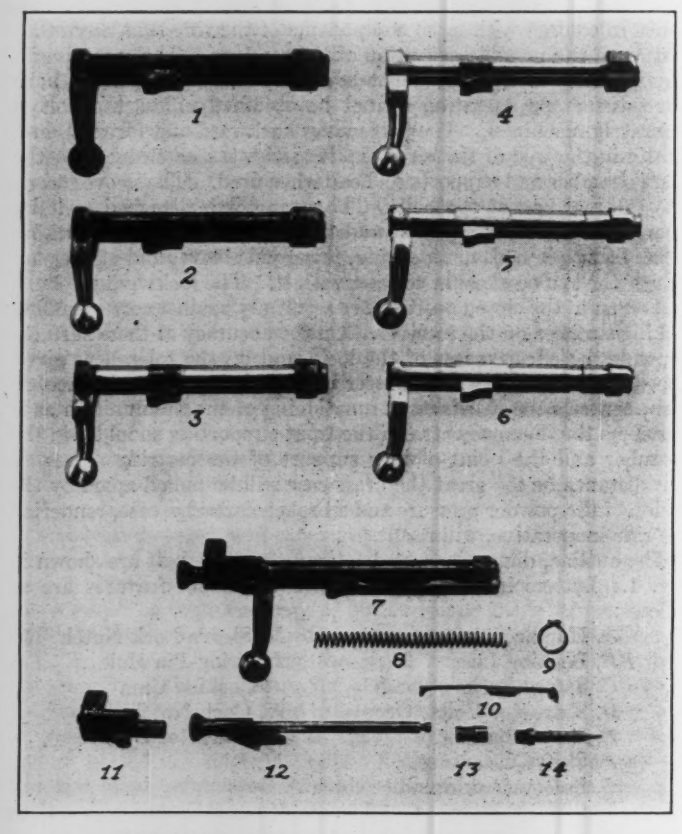

Fig. 2 Development and Assembly of Bolt

(1, Forging; 2, Handle milled, rear face finished, inside holes drilled; 3, Bolt body turned; 4, Locking lugs, extractor cam; top and bottom of handle milled; 5, Safety lock, extractor collar groove, sleeve-lock notch finished; 6, Bolt complete, cocking cam, ejector slot, and front-end operations finished; 7, Assembled bolt; 8 Mainspring; 9, Extractor collar; 10, Extractor; 11, Sleeve, with safety lock assembled; 12, Firing pin and cocking piece; 13, Firing-pin sleeve; 14, Striker.)

Metal Specifications for Bolt

The steel specified for the bolt is known locally as class "C" steel and is classed as "WD 1325" in the metal specifications of the Ordnance Department of the Army. The chemical analysis is:

Carbon	0.20 to 0.30
Manganese	1.00 to 1.30
Silicon	0.15 to 0.35
Sulphur and phosphorus, minimum	0.050

After all machining operations are completed the bolts are sent to the case-hardening department where they are heat-treated in the revolving carburizing machines No. 2, as manufactured by the American Gas Furnace Company. With the furnace at 1500 deg.

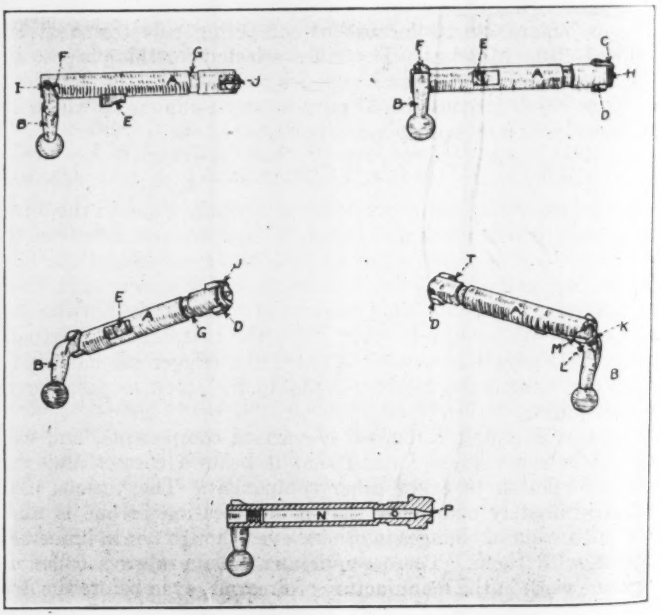

Fig. 3 Main Operations on Bolt

A—Body
B—Handle
C—Upper locking lug
D—Lower locking lug
E—Safety lug
F—Extractor cam
G—Extractor collar groove
H—Extractor groove
I—Sleeve-lock notch
J—Ejector groove
K—Sleeve stop
L—Under side of handle
M—Cocking cam
N—Firing-pin hole
O—Striker hole
P—Striker-point hole

fahr. approximately 200 bolts are charged into the furnace by means of special shovels. Charred animal bone is used for carbonizing, 80 lb. being used for each heat. Of the 80 lb. used, 40 lb. is old bone (used once) and 40 lb. fresh bone. After charging, the door of the furnace is put in place and is screwed tight. By means of an electric motor the muffle revolves once per minute. The furnace is kept at 1500 deg. fahr. for $2^3/_4$ hr. At the end of this time

FIG. 4 OPERATION 2—DRILLING THE FIRING-PIN HOLE

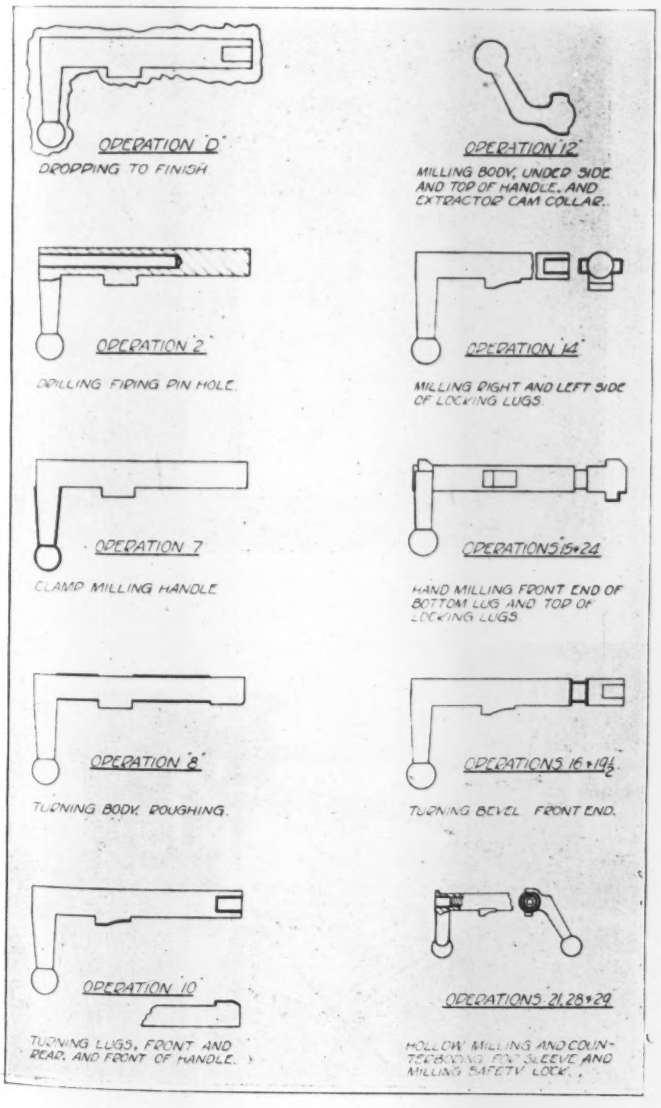
OPERATION 'D'
DROPPING TO FINISH
OPERATION '12'
MILLING BODY, UNDER SIDE AND TOP OF HANDLE, AND EXTRACTOR CAM COLLAR.
OPERATION '2'
DRILLING FIRING PIN HOLE.
OPERATION '14'
MILLING RIGHT AND LEFT SIDE OF LOCKING LUGS.
OPERATION '7'
CLAMP MILLING HANDLE
OPERATIONS 15 & 24
HAND MILLING FRONT END OF BOTTOM LUG AND TOP OF LOCKING LUGS
OPERATION '8'
TURNING BODY, ROUGHING.
OPERATIONS 16 & 19½
TURNING BEVEL FRONT END.
OPERATION '10'
TURNING LUGS, FRONT AND REAR, AND FRONT OF HANDLE.
OPERATIONS 21, 28 & 29
HOLLOW MILLING AND COUNTERBORING FOR SLEEVE AND MILLING SAFETY LOCK.

FIG. 5 SOME OF THE OPERATIONS ON THE BOLT
(Heavy lines show the metal removed during the operation.)

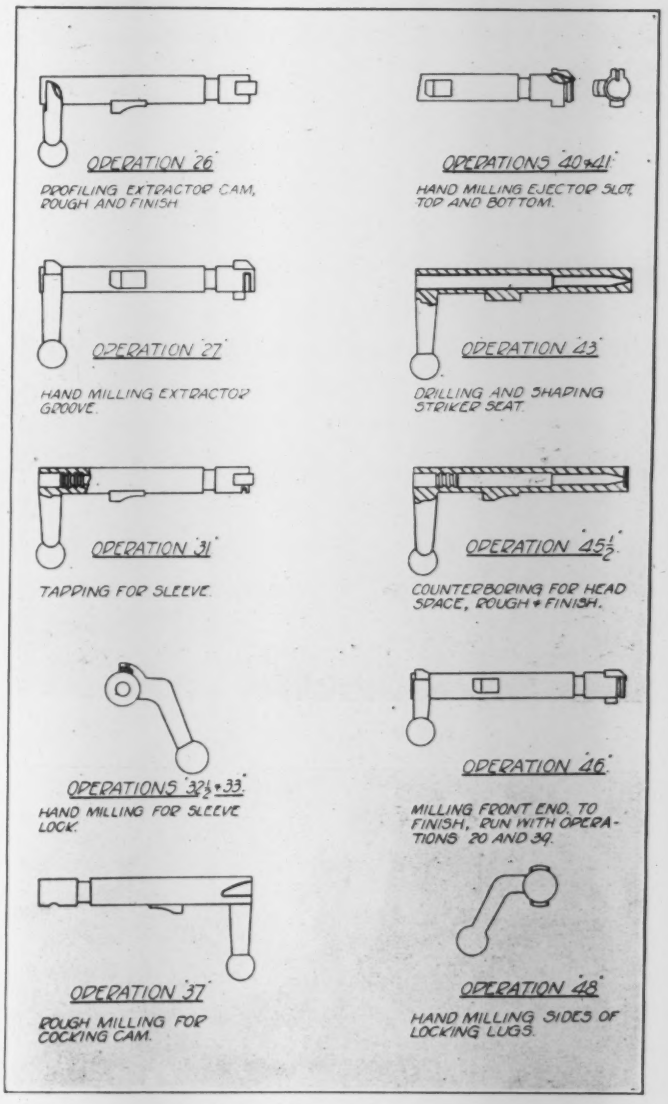
OPERATION '26'
PROFILING EXTRACTOR CAM, ROUGH AND FINISH
OPERATIONS 40 & 41
HAND MILLING EJECTOR SLOT, TOP AND BOTTOM.
OPERATION '27'
HAND MILLING EXTRACTOR GROOVE.
OPERATION '43'
DRILLING AND SHAPING STRIKER SEAT.
OPERATION '31'
TAPPING FOR SLEEVE.
OPERATION 45½
COUNTERBORING FOR HEAD SPACE, ROUGH & FINISH.
OPERATIONS 32½ & 33
HAND MILLING FOR SLEEVE LOCK.
OPERATION '46'
MILLING FRONT END, TO FINISH, RUN WITH OPERATIONS '20 AND 39.
OPERATION '37'
ROUGH MILLING FOR COCKING CAM.
OPERATION '48'
HAND MILLING SIDES OF LOCKING LUGS.

FIG. 6 FURTHER OPERATIONS ON THE BOLT
(Heavy lines show the metal removed during the operation.)

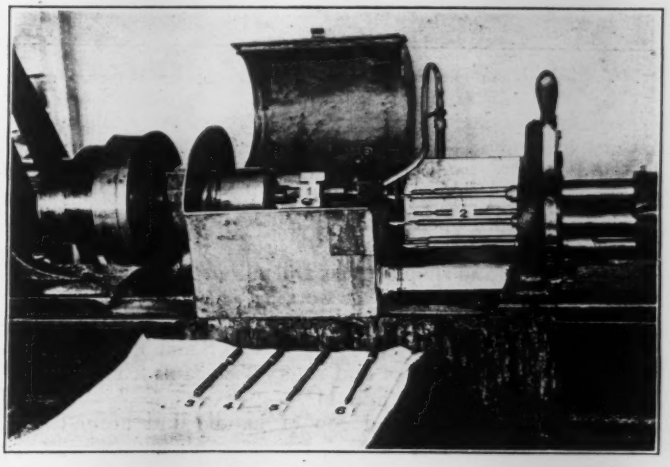

FIG. 7 OPERATION 43—DRILLING AND SHAPING THE STRIKER SEAT

the work is removed and quenched in an oil tank. The work remains in the oil until cold.

The bolts are then taken to the salt bath, heated to 1310 deg. fahr. for 5 min. and then again quenched in oil. After washing the bolts in water to remove all traces of salt, they are tempered in oil at 350 deg. fahr. for 15 min. After removing from the tempering bath, the bolts are washed in boiling soda water and are then ready for inspection.

The original hardening is for the purpose of giving a hard exterior surface to the bolt. However, in accomplishing this the interior of the bolt is likewise made hard and brittle. The subsequent heat treatment is for the purpose of reducing the hardness and brittleness of the interior, and producing in its place a core of tough, ductile steel.

How the Bolt is Manufactured

The manufacture of the bolt from forging to finished component

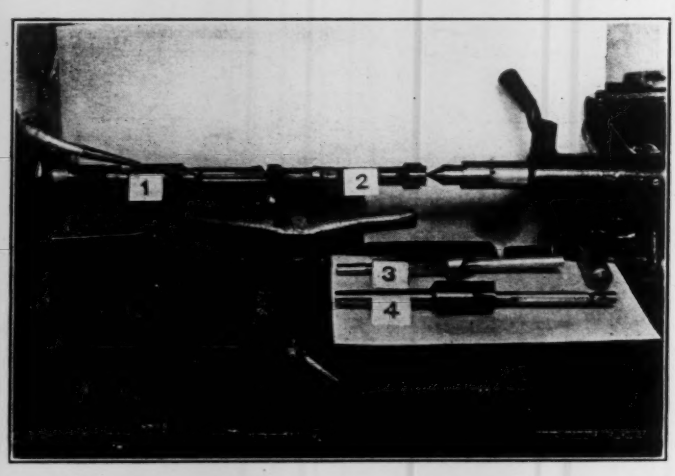

FIG. 8 OPERATION 6—FACING THE REAR END OF BOLT

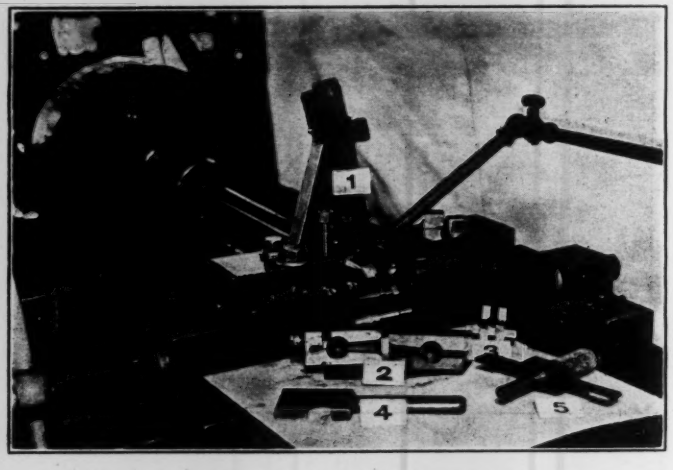

FIG. 9 OPERATION 7—CLAMP MILLING THE HANDLE

is accomplished almost exclusively by special tools, cutters, jigs, fixtures, and gages. Many standard machine tools are used in the process but a few have been specially built from the ground up for their particular purposes. In outline, the sequence of major machining and gaging operations is as follows:

a Cut to length, Operation 1
b Drilling and shaping hole, Operations 2, 3½, 43 and 43½
c Centering front end for working, Operation 5
d Facing rear end (finish), Operation 6
e Turning body of barrel, Operations 8 and 9
f Turning front lugs and safety lock, and front of handle, Operations 10 and 11½
g Milling bottom and top of handle and around barrel, Operation 12
h Milling front end and under side of bottom locking lug, Operations 15 and 24
i Milling (finish) for width of locking lugs, Operation 48
j Milling and counterboring for sleeve and safety lock, Operations 21, 28 and 29
k Profiling cams, Operations 26 and 38
l Milling for sleeve lock, Operations 32½ and 35
m Tapping for sleeve, Operation 31
n Bevel top of upper locking lug, Operation 44
o Mill ejector slot, Operations 40 and 41
p Turning rear of locking lugs to gage, Operation 44½
q Milling extractor groove, Operation 27
r Counterboring for head space, Operation 45½
s Filing and general cornering, Operation 64.

Each of the above operations is important and necessary in the proper functioning of the rifle except Operations (*a*), (*c*), and (*d*), which are used for working and gaging purposes only.

The primary gaging operations are:

a Length
b Diameter and location of bore
c Bore and underside of handle
d Rear face of bolt.

All of the other cuts, important in themselves, are dependent on one or more of the four points above for their location and gage dimensions.

There are described in the following paragraphs a few examples of some of the operations listed above. An effort has been made to

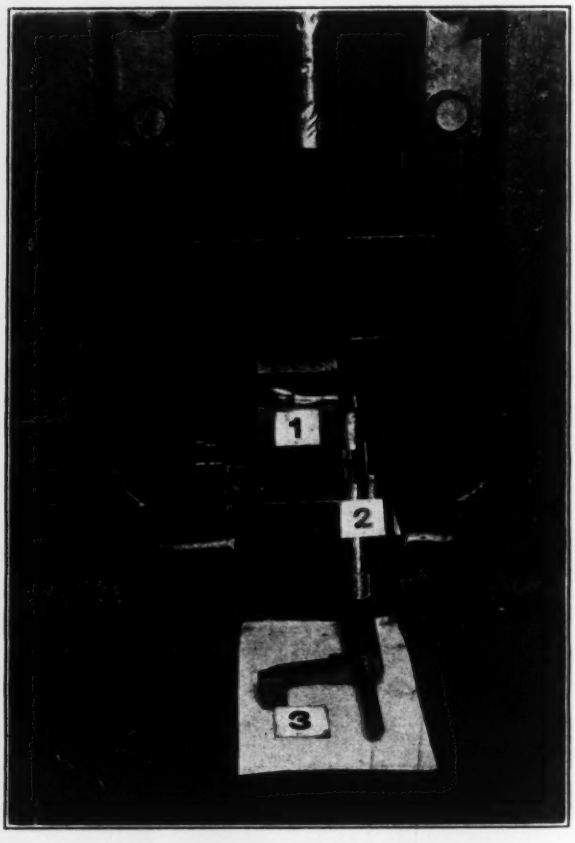

FIG. 10 OPERATION 38—BORING THE HANDLE IN HOE PRESS. PRODUCTION, 120 PER HOUR

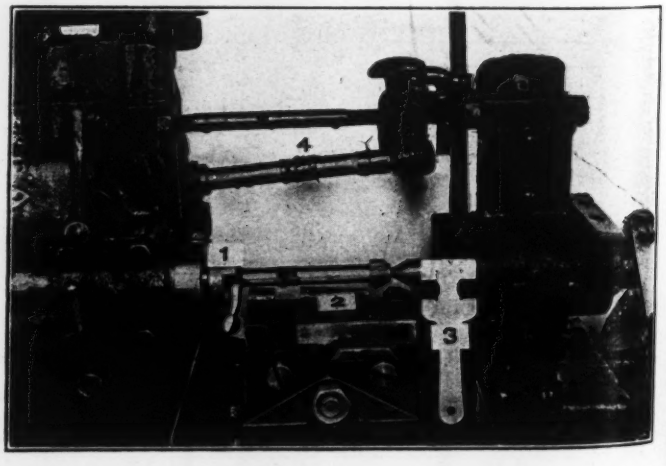

FIG. 11 OPERATION 9—TURNING BODY TO FINISH—A "SKIVING" OPERATION

show methods which are particularly adapted to gun manufacture, but which at the same time may find some application in other lines of production.

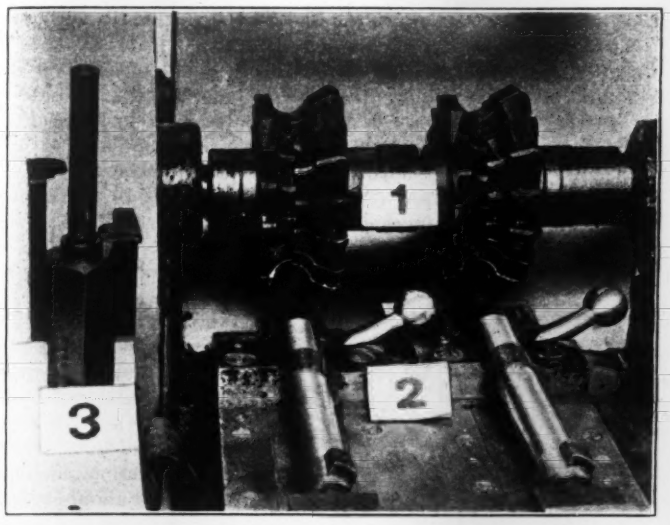

FIG. 12 OPERATION 12—MILLING BODY AND UNDERSIDE OF HANDLE

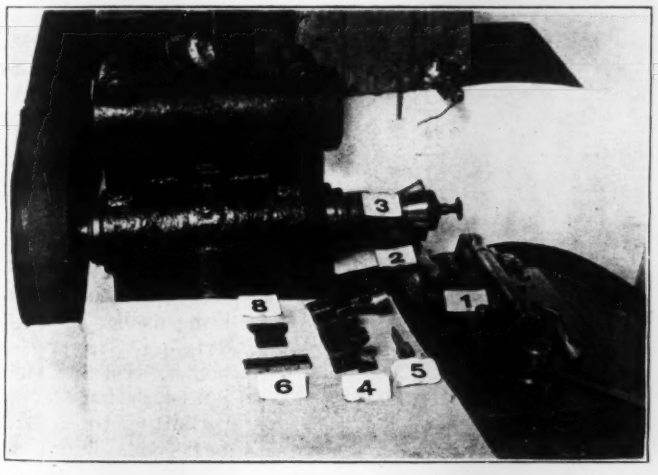

FIG. 13 OPERATION 41—HAND MILLING EJECTOR SLOT THROUGH UPPER LOCKING LUG

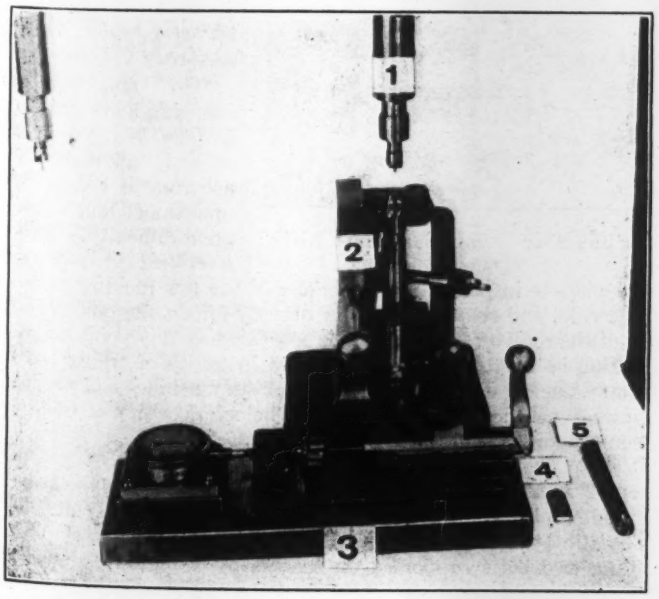

FIG. 14 OPERATION 45½—COUNTERBORING FOR HEAD SPACE, ONE OF THE VERY ACCURATE OPERATIONS

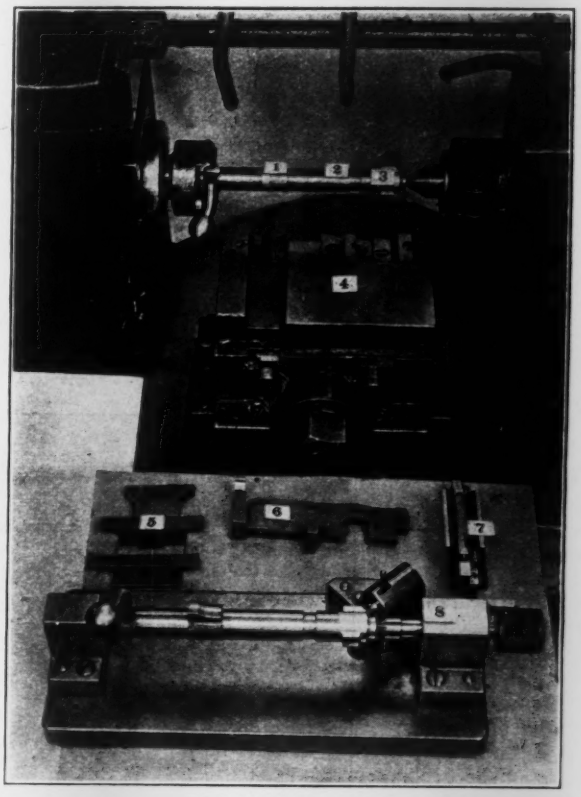

FIG. 15 OPERATIONS 16 AND 19½—TURNING BEVEL FRONT END, EXTRACTOR COLLAR GROOVE, AND TOP OF SAFETY LUG

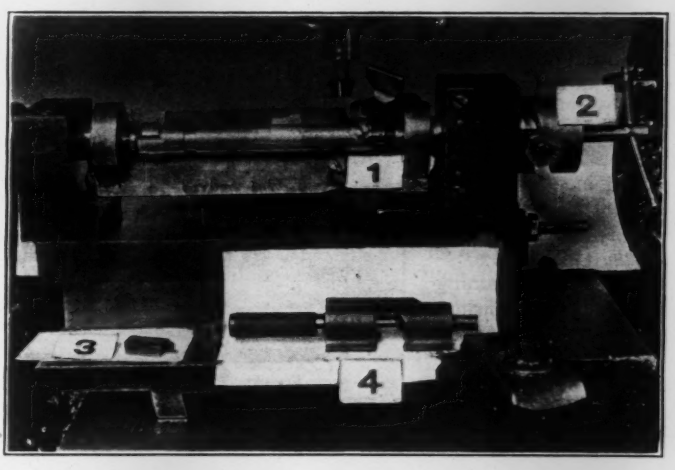

FIG. 16 OPERATION 26—PROFILING THE EXTRACTOR CAM

Drilling the Firing-Pin Hole (Operation 2).—This operation consists in drilling the main part of the firing-pin hole as shown in Fig. 5 and is performed on a Pratt & Whitney two-spindle barrel-drilling machine of the same type as those used in drilling rifle barrels at the Armory. The work is held in a clamped fixture which rotates on its own bearings, and is located by means of four screws in the base of the fixture. When a lot of forgings varies from the preceding lot, these screws are changed accordingly. The drill itself is of the single-lip type, similar to the barrel drill, the drill point being brazed to a hollow rod. The combination drill and rod is fluted on the outside and has a hole 0.05 in. in diameter, into which lard oil as a cooling medium is forced at 700 lb. pressure. The chips are forced backward along the fluting.

The set-up, fixture, gages, and drill point are shown in Fig. 4.

Six machines are run by each operator, eight pieces are produced per machine per hour, and the material is given a 100 per cent inspection. A diameter tolerance of only 0.002 in. is allowed. The bore is held close as it is used as a holding and location point in many operations that follow.

Drilling and Shaping the Striker Seat (Operation 43).—Immediately preceding this operation, the firing-pin hole and the striker hole are rough drilled, allowing the tools for Operation 43 to pass through the rear of the bolt. The machine used is a Pratt & Whitney 16-in. hand screw machine, the work being clamped in a revolving cradle fixture. Six tools are held in the turret. The order of cuts is as follows:

1 Finish drilling firing-pin hole
2 Reaming to square the end of firing-pin hole
3 Spotting striker-point hole
4 Drilling striker-point hole
5 Roughing striker seat
6 Forming striker seat.

As can be observed from the set-up shown in Fig. 7, all the tools are guided by pilots to align as nearly as possibly the center lines of the successive holes. The tools, excepting the two small spotting drills, are pinned into the pilots or arbors and float slightly. The drills are held on small chucks which screw into the pilots. Chip clearance is provided.

Depth gaging is necessary to insure that just enough stock is left for subsequent finishing operation, as an excess of stock would greatly increase the hand labor required. Only a small percentage of the output is gaged at this point.

An operator can perform work on only one machine and produces 40 pieces per hour. The tolerances allowed on both depth and location are 0.01 in.

Facing Rear End and Reaming Firing-Pin Hole in Lathe (Operation 6).—This is the first reaming operation on the firing-pin hole (to 0.420 in.) and faces the rear end of the bolt, a primary gaging surface from which most of the longitudinal dimensions are taken. The front end of the bolt has been previously countersunk for the lathe center (Operation 5). Fig. 8 shows the manner of placing the bolt in the lathe, the combination reamer and facing tool used, and the gage.

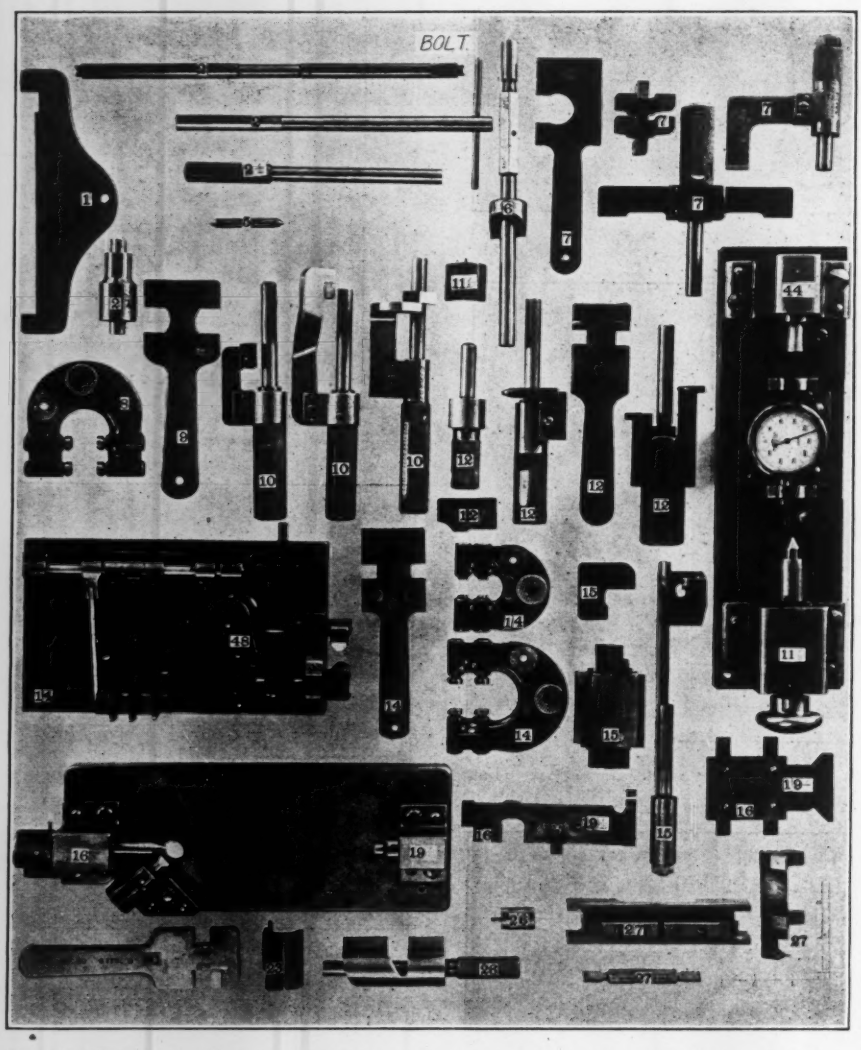

FIG. 17 THE GAGES USED IN THE MANUFACTURE OF THE BOLT OF THE SPRINGFIELD RIFLE

One hundred and fifty pieces are produced per hour per machine from one operator. The cut is given a 100 per cent inspection and the diameter tolerance allowed is 0.002 in. As with Operation 2 mentioned above a close tolerance is held, for if this hole be not of the proper size and in proper location, many other cuts will not be true.

Clamp Milling the Handle (Operation 7).—Fig. 9 shows an interesting operation on milling the handle and ball of the bolt. The machine used is one especially built at the Springfield Armory for this work and has been in use since the beginning of the manufacture of the Model of 1903 rifles. The bolt is held in a driving fixture so that the center line of the handle will be perpendicular to the hole in the bolt. Clutch control is provided. One cut is made with the cutters which are hand fed on to the work by means of right- and left-hand screws. The forms of the cutters and gages are shown in the figure. An operator produces 65 pieces per hour. The average life of tools between grindings is 1000 pieces. A small percentage of the bolts are inspected at this operation and the tolerances allowed are 0.01 in. for the diameter of the handle and ball, and 0.015 in. for location.

Bending the Handle (Operation 58).—The slight offset given to the handle after the milling operation just described is necessary in order that the ball may clear the fixtures used in succeeding turning operations. This slight bend has been introduced within the past few years and is not to be found on the earlier rifles produced. A Hoe hand screw press is used, according to the set-up shown in Fig. 10. The production is 120 per hour, the inspection is very limited, and the tolerances reasonably great.

Turning Body to Finish (Operation 9).—This type of turning is performed on a Pratt & Whitney automatic milling machine, and uses a flat forming tool and shearing undercut. It is actually a skiving operation and was introduced in the manufacture of the bolt about twenty years ago in preference to the usual turning methods, as it is peculiarly adapted to this component whose lugs and handle interfere with ordinary lathe methods. The cutter is made in sections to allow the lugs to pass through it. It is a comparatively simple tool to form and is economical in manufacture. Fig. 11 shows the bolt held on centers and being driven by special driving center and holder. Oil lubrication is used, the large oil pipe permitting the work to be flooded. Two skiving cuts are used, a roughing cut of about 0.040 in. and a finishing cut of about 0.015 in., which leaves a bright, smooth surface.

"Go" and "no go" snap gages are used and a 0.0015-in. tolerance only is allowed. The accuracy is consistently maintained and without great difficulty. A close tolerance is required and every piece is inspected as this is one of the few moving surfaces of the rifle, and the bolt diameter directly affects the bolt fit in the well of the receiver. Any undue looseness at this point causes a variation in weight of trigger pull and in safety of trigger mechanism. Each operator is responsible for six machines and produces 25 pieces per hour per machine. The average life of tools between grindings is upward of 5000 pieces.

Milling Underside of Handle and Right Side of Bolt Body (Operation 12).—This operation, illustrated in Fig. 12, shows the general method employed for several of the milling cuts on the bolt. The automatic type of miller is used. A special fixture is employed holding two bolts supported on centers by V-blocks clamped by cams on the bolt ends. A similar machine equipped in like manner mills the top side of the bolt and the upper surface of the extractor cam.

The underside of the bolt handle, determined in this operation, is extensively used as a bedding point in both the operations of manufacture and gaging. It will be observed that most of the gages which locate lugs and surfaces have a bearing point on this shoulder, which also determines the bolt location in various fixtures.

Each operator runs six machines, produces 25 pieces per hour from each, and gets an average life of tool between grindings of 2000 pieces. A 100 per cent inspection is accomplished and the tolerance is held to 0.002 in.

Hand Milling the Ejector Slot (Operation 41).—Cutting the slot in the top lug in order to permit the proper functioning of the ejector is a small operation requiring refined practice. The ejector works through the slot to throw the fired cartridge case out of the rifle, and the slightest interference would cause malfunctioning and would burr the ejector. The set-up is shown in Fig. 13. A hand miller with form and roller is used. The form and the saw milling cutter produce the right contour of slot. Formerly two separate operations, a top and a bottom cut, were required. A cam fixture holds the work, the underside of the handle determining the bolt's location in the fixture. The cut is gaged for depth, for width, for location from side of lug, and for depth and location of radius on bottom of slot.

An operator handles one machine, with a production of 165 pieces per hour. Each piece is inspected and the tolerances permitted are 0.002 in. for width of slot, 0.010 in. for location, and 0.005 in. for depth.

Counterboring Forward End of Bolt for Distance or "Head Space" (Operation 45½).—Fig. 14 shows the somewhat complicated fixture and the gages used in performing this operation. The rear face of the locking lugs has been previously turned with great accuracy, measurement being made from the rear face of the bolt. In Operation 45½ the measurement is made from the rear face of these lugs to the counterbored surface. The head-space adjustments are dependent upon the surfaces just mentioned and are of primary importance in determining the safety of the weapon and the proper functioning of the ammunition.

Formerly two operations were provided, roughing on a spindle drill and finishing in a hand fixture. They are now performed as one operation on an Allen two-spindle drill press which gives the required finish and accuracy on the second cut. The work is clamped by an equalizing bar in the drill jig, and bedded on the rear face of the locking lugs. Three gages are used: these are the indicating dial gage, checking the distance from the rear of the locking lugs to the counterbored surface (or cartridge seat); a plug gage for the diameter of the counterbored surface and its location from the firing-pin hole; and a straight edge for the cartridge seat.

Forty-five pieces are produced per machine per hour by one operator. The life of the tool between dressings is 500 pieces. A careful inspection of every piece is required and a tolerance of 0.0015 in. is rigidly maintained.

Turning the Bevel at the Front End of the Bolt, the Extractor Collar Groove, and the Safety Lug (Operation 16–19½).—The set-up and operation, shown in Fig. 15, are somewhat similar to the skiving operation referred to as Operation 9. The gages used are shown in the figure. The tolerances allowed are fairly liberal with the exception of the diameter of the extractor collar groove which is held to 0.002 in. so that the functioning of the extractor may be certain. The average life of the tool between grindings is 1500 pieces.

Profiling the Extractor Cam (Operation 26).—Fig. 16 illustrates the method of profiling the extractor cam, and a similar process is followed in producing the cocking cam on the underside of the bolt. This cam gives primary extraction to the cartridge case and is an important factor in the smoothness and ease of operation of the bolt in the receiver. A Reed-Prentice profiler is used. The bolt is held clamped on centers on a rotating fixture, the bedding point being the shoulder on the underside of the bolt handle. The guide cam shown at the right of the fixture produces the desired profile. Two cuts are made, one roughing, and a finishing cut of about 0.015 in. An operator handles one machine and produces 65 pieces per hour. The life of the cutter between grindings is 2500 pieces. A rigid inspection is maintained and a longitudinal tolerance in the location of the cam of 0.002 in. is allowed.

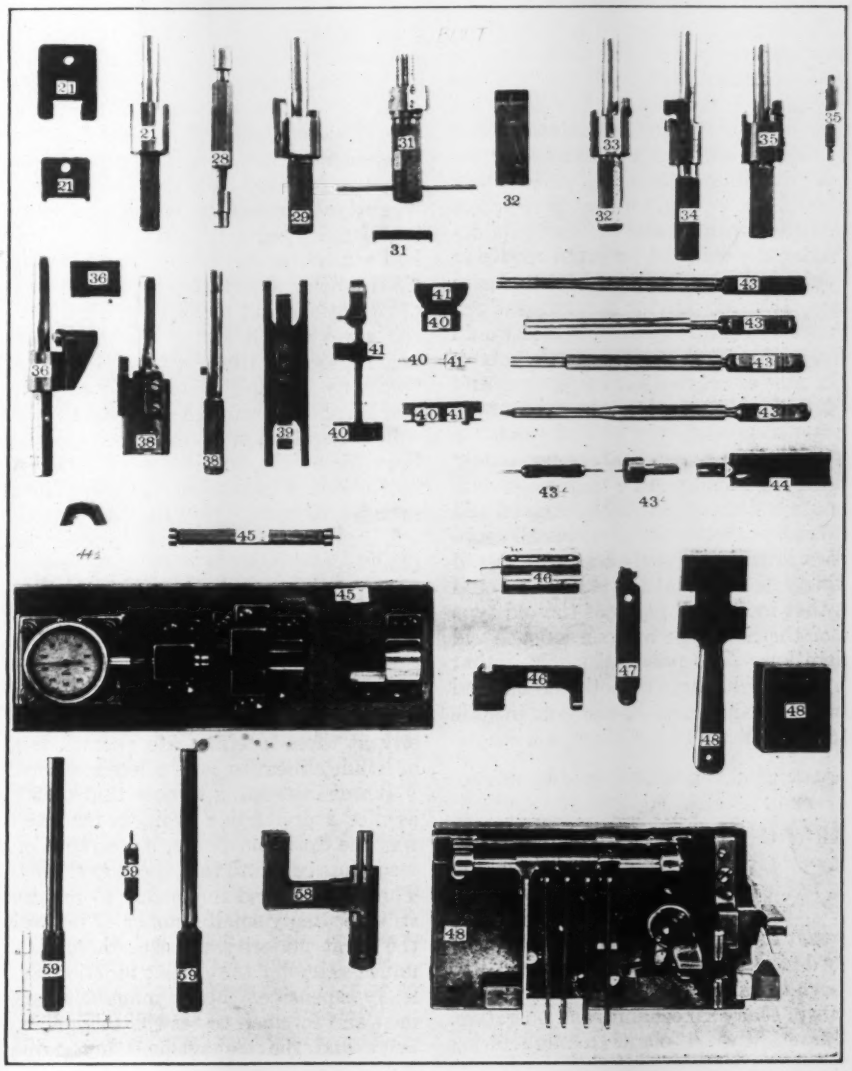

FIG. 18 THE GAGES USED IN THE MANUFACTURE OF THE BOLT OF THE SPRINGFIELD RIFLE

HOW THE RIFLE IS GAGED

The system of gaging used in the manufacture of the Springfield rifle is the outgrowth of the gage methods used for its predecessor, the Krag-Jorgensen rifle. The Krag gages were in turn developed from the older 1873 and 1884 models of the Springfield rifle, although these earlier rifles were of very different operation and type. In many cases old gages, in the interest of economy, were used by the necessary modification for the newer models of rifles, and the system of gages thus built up represented merely an evolution rather than a complete and systematic set of gages designed in accordance with the proper technical and engineering viewpoint. It can be said that the first set of gages used in the manufacture of the Springfield rifle allowed no tolerances whatever, all of the gages having been manufactured in accordance with a flat dimension. It is obvious, and was obvious, that it is impossible to manufacture on a production basis without some allowance or leeway in dimension on account of inaccuracies in the machine, the tools, and the hand of the operator. With the earliest system of gages in vogue it

is therefore apparent that the inspector actually carried the tolerances "under his hat." In other words, the inspectors had been in the employment of the Springfield Armory and had been doing this particular kind of work for such a long period of years that they knew from the amount of light showing between the gage and the work whether or not the work would be satisfactory for the purpose for which it was required. The satisfactory operation of a system of this character is based entirely upon the knowledge of the inspectors and not upon the sufficiency of the gages. Such a condition is incompatible with mass production or with changing personnel.

Shortly after the outbreak of the World War in 1914, large orders for munitions were given to manufacturers of this country and the production of war supplies was, for a time, the most important product of our metal-working plants. Production in quantity was the keyword, and it became more and more evident as the weeks went by that production in quantity meant interchangeable manufacture, which in turn depended finally upon proper gaging methods as a means of determining the degree or satisfactoriness of interchangeability. This condition brought more forcibly to the attention of the authorities at Springfield Armory the fact, already well known to them, that the system of gaging employed at their establishment required revamping in order to be at all satisfactory for use by outside concerns, should it ever be desired to give orders for the Springfield rifle to commercial plants, and for high production of rifles at the Armory under the enlarged program requiring additional operators, additional inspectors, and a large turnover of labor. Steps were accordingly taken to provide new gages which would embody the latest principles of gage engineering and would place the gaging system upon a modern and scientific basis. After long study and investigation a new set of master, inspection, and working gages was designed and master reference gages were produced.

If the benefits of the new study of gages were to be immediately realized by the Springfield Armory it would require that the system of gages that had long been in use be immediately discontinued and that new gages built in accordance with the new drawings be substituted therefor. The expense involved in such a scheme would be very great. It was accordingly decided that the old gages would be continued on the job, but that individual gages of the old type would be replaced by gages of the new type as soon as such old gages showed wear or deterioration. The practical result is that there are now in the shops at Springfield gages of both the old and the new design, and the figures showing gages of the bolt include those that have been long in use as well as those of the newer school.

THE PROBLEM FACING AMERICAN ENGINEERS IN RIFLE MANUFACTURE

The manufacture of the bolt of the rifle as its production is followed at the Springfield Armory gives an example of the highly specialized use of tools, jigs, fixtures, and gages which is typical of the gun-making industry. All of the information transmitted to the operating personnel is that conveyed by means of the appliances and fixed gages, specially designed and built for each operation. This equipment, as it is, has been found necessary and has been produced to meet the requirements of today's mechanics and operators. Like conditions prevail in practically all plants manufacturing small-arms weapons in this country. The operators available for high-class work appear to be diminishing in number and in skill. To maintain supremacy, the American engineer will in the future be required to design even better, to plan even more skilfully, and to produce even more scientifically the material, fixtures, and gages that will insure proper functioning of the article under manufacture —made, however, by the hand of an operator whose skill is diminishing year by year.

Discussion

EDWIN PUGSLEY[1] submitted a written discussion of Major McFarland's paper in which he said that nowadays in a commercial manufacturing plant the last thousandth or fraction of a thousandth was what cost and it was therefor the aim of every manufacturer to have his product designed so that he might use the greatest tolerance with the least interference with interchangeability. If extremely small tolerances created a product which was better from a military standpoint, the question of dollars-and-cents cost as ordinarily applied was of minor importance, but it should be remembered that undue tolerances were liable to cost time, which was important from a military standpoint where a pure dollars-and-cents cost might not be.

In the light of his experience Mr. Pugsley believed that the most important starting point was a correct set of model drawings plainly and simply dimensioned, with every dimension bearing a reasonable manufacturing tolerance. These tolerances were extremely important and must be laid out by an engineer entirely familiar with the requirements of each part, as it was essential that there should be no interferences in the tolerances and that the tolerances be as ample as possible in order to reduce the cost of tools, fixtures, gages and production.

Generally speaking, his company considered a tolerance of ± 0.001 in. close enough on ordinary gun work, with the exception of a few dimensions which it was necessary to hold considerably closer. They believed that the most important part in successful interchangeability was the proper selection of so-called locating points, sometimes called holding points or bedding points, by which was meant the surfaces which were established early in the machining of the piece and used, first, to locate the work in the fixture, and second, to gage from. The locating point should be a good-sized hole or a surface which could be established early in the list of operations and maintained until the end. It was essential that the gages should locate from the same point that the piece was held or located from in the fixture, and it was highly undesirable to change locating points or adopt a locating point which must be machined off toward the finished end of the operation list.

The application of these principles to the manufacture of the Springfield rifle, so clearly set forth by the author, gave a good indication of what was required in rifle manufacture, bearing in mind, of course, that the bolt was merely one component of the gun and must function satisfactorily with the receiver, barrel, and other components.

E. J. Bryant,[1] referring to the fact that it had been necessary on several of the operations described in the paper to hold them to close tolerances so that the part might be located accurately at subsequent operations and that the final product be within the required limits, wrote that he believed more attention should be given to the development of fixtures and tools that would function properly at these intermediate operations and eliminate the necessity of holding them to close tolerances for the purpose mentioned.

It was interesting to note that on a piece of apparatus that was as nice a production problem for interchangeable manufacture as was the Springfield rifle, a tolerance of 0.002 in. was considered a very close one, and that the closest tolerance required was 0.0015 in. There was a tendency today to require that tolerances be held to an exceedingly small number of ten-thousandths of an inch, and in the great majority of cases these close tolerances were not only unnecessary for the proper functioning of the parts but were needlessly expensive. Many manufacturers were still permitting workmen and foremen to set the tolerances instead of having the engineers and the management determine their proper values, and it was surprising to find that this method was still being followed to some extent by one of this country's main sources of supply for military rifles.

F. W. Roys[2] and H. P. Fairfield[3] wrote that it was apparent that the bolt was a component of the rifle requiring the finest kind of workmanship, and yet one that had to be made in quantity by private manufacturers in time of emergency. It might appear to some that special machines could be designed to perform certain of the operations described more efficiently, but such machines would hardly be available in the various shops which would have to handle the work in time of emergency. The problem appeared

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[1] Mgr. Gage Dept., Greenfield Tap & Die Corpn., Greenfield, Mass. Assoc-Mem. A.S.M.E.

[2] Head of Dept. of Mech. Engrg., Worcester Polytechnic Institute, Worcester, Mass. Mem. A.S.M.E.

[3] Professor of Machine Construction, Worcester Polytechnic Institute, Worcester, Mass. Mem. A.S.M.E.

to be one of establishing production methods that it would be possible to put into operation in any well-selected plant in a minimum time. Hence the employment of ordinary equipment instead of special machines.

One thing at the Armory that had struck the writers very forcibly was the great care that had been given to the preparation of drawings, operation charts, and directions for everything in connection with the production of finished rifles. These directions might be issued in case of emergency to any selected private manufacturer so that the methods so carefully worked out at the Armory could be made to yield in a minimum time an enormously increased production.

Frederick T. Moore,[1] in a written discussion, said that the late war had shown a great many who were immediately connected with governmental affairs the great difficulty of producing the tools, fixtures, and gages necessary for maintaining the accuracy, quality, and quantity of output needed, but that it almost seemed as if the conditions then brought to the attention of the country at large were now being lost sight of. He was acquainted with the system in use at the Springfield Armory and believed that for its purpose it left little to be desired. Those engaged in arms construction were aware of the importance of proper working tolerances and were giving consideration to them in both the design and manufacture of their products, realizing that in time of stress so many green workmen had to be taken on and taught the requirements of satisfactory production that such tolerances and practical gaging methods were most essential.

B. H. Blood,[2] who opened the oral discussion, said that during the war a great many firms struggled with the problem of interchangeability, the use of gages, and other kindred matters with which they were unfamiliar, and were inclined to be censorious as regarded the limits to which they were asked to work, but today they were reasonably converted to the system. As an illustration of the growth of the gaging idea, he would say that during the past three years, which had been a period of depression in the machine-tool industry, the firm with which he was connected had done more business in gages outside of small-arms manufacture than in its entire fifty years' previous history.

Information regarding the time required to assemble the finished rifle would be of interest. Mr. Blood stated that he knew of instances where the assembling time had been very much reduced by the employment of proper gaging throughout the operations and finally gaging so as to insure greater interchangeability.

It was generally agreed that interchangeable manufacture had started with small-arms work, but it was not long in spreading to the production of such mechanisms as bicycles, typewriters, and automobiles. While all looked upon war as an expense and waste of money, Mr. Blood nevertheless believed that the development of interchangeable manufacture which grew out of the late conflict could be looked upon as a real asset to the industries of the country because of the educational work that had resulted from it.

A. L. DeLeeuw[3] said that he could not agree with the author that the number of skilled mechanics in the country was decreasing. On the contrary, he believed that at the present time they were over 20 per cent more in number than they were thirty years ago, only instead of doing the actual work of manufacturing they were now doing preparatory work therefor—making tools, dies, machines, and gages. The idea that the all-around mechanic was disappearing seemed to be getting such a hold that many thought the whole machine-tool industry would eventually go to the dogs simply for lack of skilled workmen. In Mr. DeLeeuw's opinion their number was constantly increasing, but there might come a time when the demands of industry could not be met because of the impossibility of finding a large enough percentage of the population with the ability to become skilled mechanics.

The general idea of the skilled mechanic of years ago was that of a man who, in addition to manual skill, had some knowledge of all the machine tools in existence and could use them all—lathe, milling machine, drill press, planer, and shaper. An all-around mechanic of that type today, however, would have to be able to operate a multitude of new tools that have come into general use, and because there were no such men now it was claimed that there were no skilled mechanics.

The things that skilled mechanics could do nowadays compared very favorably with what they were able to do thirty or forty years ago. The making of fine dies, for example, was an art that had been developed since then, and the fact that all of the die makers that had been needed had been supplied in that short period showed not only that the same amount of skill was still available, but that the men possessed great adaptability.

F. B. Gilbreth[1] and John Younger[2] both agreed with Mr. De Leeuw that the number of skilled mechanics was larger than at any previous time. Mr. Younger pointed out that they were to be found not only in the machine-tool industry but in the garages of the 100,000-odd automobile dealers of the country, engaged in maintenance, service, and repair work. They were becoming skilled thinkers, and the skilled thinker was a better man than the skilled mechanic.

Erik Oberg[3] said that there was scarcely any lack of skilled mechanics at the present time. There were literally thousands of them working in other lines because of the unfortunate conditions in the machine-tool industry that made it impossible to compensate for skilled work at rates that attracted the more ambitious men. The machine-building industries were not getting enough for their products to be able to pay the wages that were current for a similar grade of labor in other fields. For example, a first-class tool maker received even less than a street-car conductor. If tool builders could afford to offer, say, 75 per cent of the wages prevailing in the building trades, Mr. Oberg believed they would have no trouble in getting all of the skilled mechanics and tool makers back into the industry that they wanted.

The author, in closing, expressed his gratification with the interest shown in the discussion. The Small-Arms Section of the Ordnance Department, he said, as regarded its engineering activities, was concentrating its efforts along two main lines of endeavor: first, to have on hand complete specifications, drawings and samples of rifles, pistols, bayonets, ammunition, and other items of current equipment, so that in case of emergency complete specifications could be immediately furnished to those who were to produce them on a large scale; and, second, to develop and experiment with new types and designs so that when the present current types become obsolete or obsolescent, the best known type might be ready to be put at once into production.

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[2] Gen. Mgr., Pratt & Whitney Co., Hartford, Conn. Mem. A.S.M.E.
[3] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

[1] Pres. Frank B. Gilbreth, Inc., Montclair, N. J. Mem. A.S.M.E.
[2] Editor and Publisher, *Automotive Abstracts*, Cleveland, O. Mem. A.S.M.E.
[3] Editor, *Machinery*, New York, N. Y. Mem. A.S.M.E.

A New Mild Steel

THERE is now in existence a mild steel with a higher elastic limit than ordinary mild steel. This elastic steel is the development of Mr. F. G. Martin, a metallurgist of Liverpool. This elastic steel has an elastic limit of 16 tons to 17 tons per square inch, as compared with eight tons for ordinary mild steel. Its ultimate tensile strength is 30 tons to 35 tons per square inch, not very different from the 28 tons to 32 tons per square inch for ordinary mild steel. Its ductility is as good as that of ordinary mild steel, as evidenced by its elongation of 20 per cent in 8 in., and this is obviously an important attribute of it. The elastic steel is capable of withstanding continuous reversals of stress to a very much greater extent than ordinary rolled mild steel. It will withstand 10 million reversals at a stress equal to its elastic limit of, say, 16 tons, whereas ordinary mild steel will break down at about one million reversals at a stress equal to its elastic limit of eight tons. The modulus of elasticity of the elastic steel is about eight per cent greater than that of ordinary mild steel. Its corrosive properties are the same as those of ordinary mild steel. The cost of this steel is about 25 per cent greater than that of ordinary mild steel, but its price would drop as its use became extended, as was the case with ordinary mild steel.—G. W. Barr, F. G. Martin and A. T. Wall in a paper read before the Institution of Naval Architects, London, April 11, and published in *Engineering*, April 18, 1924, p. 510.

Lumber Handling in an Automobile-Body Plant

Yard Layouts for the Efficient and Economical Handling, Storing, Drying, and Cutting of Lumber—Steam Consumption of Dry Kilns—Equipment for Handling Lumber, Including Dry-Kiln Trucks and Transfer Cars, Power Transfer Cars, Lumber Lifts, Stackers, Etc.

By B. NAGELVOORT,[1] DETROIT, MICH., AND THOMAS D. PERRY,[2] GRAND RAPIDS, MICH.

THE lumber yard of today is materially different from that of ten or more years ago, and has become more important relatively, as it now frequently presents the greatest opportunity of keeping down costs by efficient operation. Machinery, tools, and other equipment have passed through interesting cycles of development. Their relative values to the industry can be best understood by reference to these changes.

Time- and labor-saving devices are continually being introduced to decrease the number of individuals employed in all branches of industry, including the handling and storage of lumber, as witness the modern lumber yard which requires fewer men to operate than one of ten years ago. But along with this development of means to reduce the labor per thousand feet of lumber handled to a minimum has come a multiplicity of requirements of this branch of the body industry which call for consideration.

The ordinary common board has never received much attention from engineers in the material-handling branches, perhaps because it is not large enough for power appliances, or is too awkward and clumsy for chain or belt conveyors. The time has now come, however, when lumber is of such value and common labor demands such wages that it is necessary to economize in handling expense in order to conserve as much as possible of every board. Hence the necessity for rapid turnover of lumber stocks, with a minimum of labor requirement.

Dry-kiln storage on wheels answers this requirement, provided the investment in land and equipment does not exceed reasonable limits. The growing demand for such equipment is rapidly developing standards, both of types and sizes.

Yard Layout

Considerable study is required to arrange the laying of rails for such a lumber yard on wheels, with convenient and economical relation to the railroad sidings, the transfer tracks, the dry kilns, the green- and dry-lumber storage, and the delivering of dry lumber to saws or surfacers.

Rail weights should be from 30 to 40 lb. per yd. A 35-lb. rail, when supported by cement piers every six feet, will carry loaded kiln cars without serious deflection.

Lumber on kiln cars is said to be end piled when the boards are parallel to the rails, and cross-piled when at right angles thereto. The direction of piling is usually determined either by the entrance to the wood mill or by the location and shape of the dry kilns.

Loads are normally 16 ft. long by 6 ft. wide for cross-piling, and 16 ft. long by 8 ft. wide for end piling. While a considerable proportion of ordinary lumber will be less than 16 ft. long, yet this is the standard, and aisles of 2 ft. or more must be allowed between loads when spacing yard rails. The rail spacing for end piling is usually 6 ft. on centers, and for cross-piling with three rails is 11 ft. outside centers.

The height of loads may extend to 9 ft. above the rails on cross-piling and 10 ft. on end piling. Higher loads become unstable and do not dry evenly in the kilns.

Dry-Kiln Trucks

The best types are made of structural-steel angles or channels and provided with double-flanged malleable-iron wheels mounted on roller bearings (see Fig. 1). The separators and hangers should be welded or riveted, never bolted. Cast-iron parts are unnecessarily heavy and break easily under strain, especially wheel flanges. The standard sizes of a well-known make are given in Table 1. The foundation under lumber and on top of trucks should be of

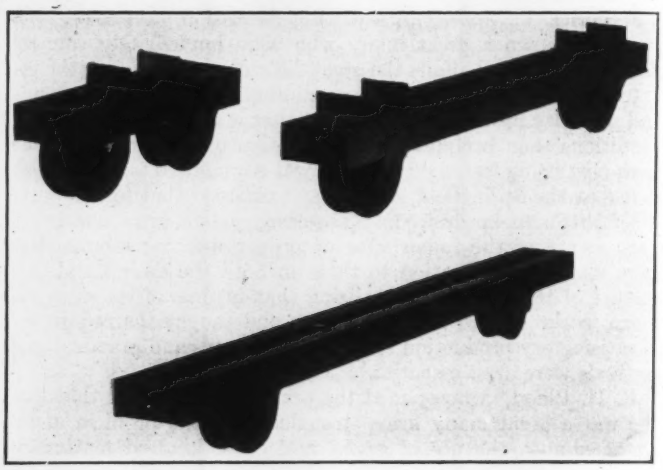

FIG. 1 20-IN., 4-FT., AND 6-FT. STEEL DRY-KILN TRUCKS

2-in. plank, crown up, on cross-piles, and either 6-in. by 6-in. timbers or 4-in. I-beams on end piles. In order to have plenty of ventilating space in the loads only two-thirds of the horizontal area should be occupied by boards, and the stickers should be equal in thickness to boards. A capacity schedule is given in Table 2. Some allowance should be made for lumber less than 16 ft. long. For practical purposes in body work 4000 ft. is taken as standard capacity on cross-pile and 6000 on end pile, both based on a general average of 2-in. thickness.

TABLE 1 STANDARD TYPES AND SIZES OF DRY-KILN TRUCKS

Length ft-in.	Width in.	Height in.	Wheel Diam., in.	Weight, lb.	Kind
20	4 3/4	6 1/4	5	37	End pile, 1 pair wings
20	4 3/4	7 3/4	6 1/2	41	
20	4 3/4	9 1/4	8	48	
4- 0	4 3/4	6 1/4	5	58	End pile, 2 pair wings
4- 0	4 3/4	7 3/4	6 1/2	62	
4- 0	4 3/4	9 1/4	8	68	
5- 0	6	7 3/4	6 1/2	64	Cross-pile, without wings
5- 0	6	9 1/4	8	70	
5- 6	6	7 3/4	6 1/2	67	
5- 6	6	9 1/4	8	73	
6- 0	6	7 3/4	6 1/2	70	
6- 0	6	9 1/4	8	76	

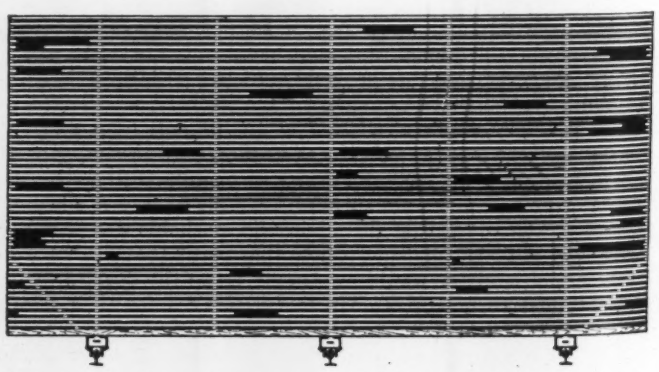

FIG. 2 SIDE VIEW OF LOADED KILN CAR WITH THREE CROSSWISE TRUCKS 6 FT. LONG

Kiln Transfer Cars

Standard equipment is usually 10 3/8 in. high so that the yard

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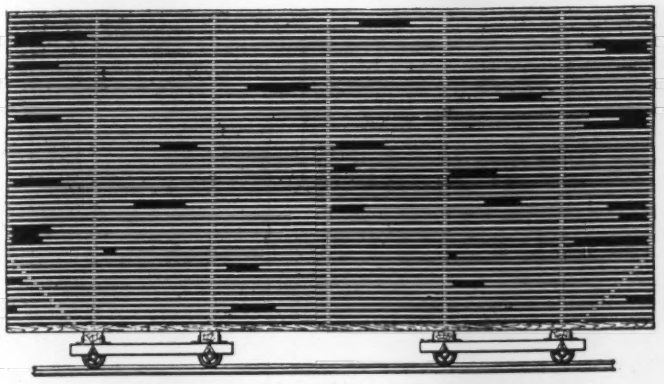


FIG. 3 SIDE VIEW WITH TWO ENDWISE 48-IN TRUCKS

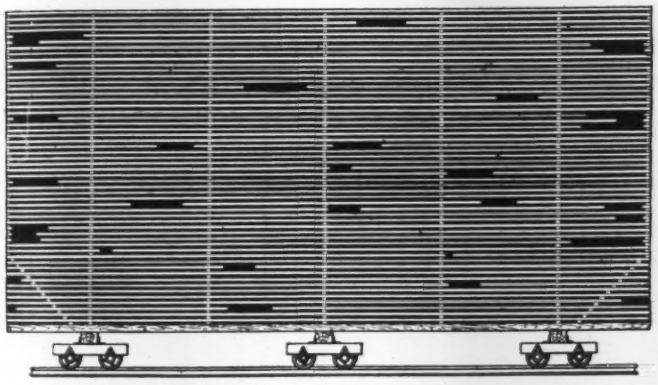


FIG. 4 SIDE VIEW WITH THREE ENDWISE 20-IN TRUCKS

TABLE 2 KILN-CAR CAPACITY IN BOARD FEET WITH LOADS 16 FT. LONG

(Based on 6½-in. diam. truck wheels, 2-in. plank base on cross-pile, and 4-in. I-beam girders on end pile. See Figs. 2, 3 and 4.)

	Lumber thickness, in.	Sticker thickness, in.	Height above rail, ft.	Width of load, ft.	Courses of lumber	Capacity, ft. B.M.
Cross pile	4/4	1	9	6	50	3200
	6/4	1	9	6	40	3840
	8/4	1	9	6	33	4220
	8/4	2	9	6	25	3200
	10/4	2	9	6	22	3520
	12/4	2	9	6	20	3840
End pile	4/4	1	10	8	54	4470
	6/4	1	10	8	43	5480
	8/4	1	10	8	36	6120
	8/4	2	10	8	27	4590
	10/4	2	10	8	24	5090
	12/4	2	10	8	22	5610

channels or aisles for these cars need not be inconveniently deep and the kiln operating or control rooms, over which they usually operate, may not be forced too far underground. The cross- and end-pile types are illustrated in Fig. 5. Successful transfer cars must be sturdy and rigid so that the upper rails may be easily matched for moving kiln cars on and off. Standard sizes and gages are given in Table 3.

TABLE 3 STANDARD SIZES AND GAGES OF TRANSFER CARS

	Cross-Pile	Medium End Pile	Long End Pile
Length, overall	11 ft. 6 in.	14 ft. 0 in.	18 ft. 0 in.
Width, overall	5 ft. 6 in.	5 ft. 6 in.	7 ft. 6 in.
Height, rail to rail	10³/₈ in.	10³/₈ in.	10³/₈ in.
Gage, inside lower rails	4 ft. 8½ in.	13 ft. 2½ in.	16 ft. 2½ in.
Rail spacing top, centers	5 ft. 6 in.	5 ft. 0 in.	5 ft. 0 in.
Size of channel sides	6 in.	6 in.	6 in.
Diameter wheels, inside flange	10 in.	10 in.	10 in.
Wheels, number of	4	9	6
Weight for shipping, lb	1000	1250	1650

CONDITIONS AND LIMITATIONS

The plans shown in Figs. 6 and 7 are actual studies which were prepared recently to meet the requirements of an increased-production program in one of the large automobile body plants in Detroit. There was available a parcel of vacant land 350 ft. by 550 ft. adjacent to the existing six-story buildings, and it was proposed to utilize the ground or grade floor for lumber storage, drying, and handling, anticipating the probability that the six-story buildings would later be extended over all or part of the lumber layout.

The daily output required was 50,000 board feet of assorted body

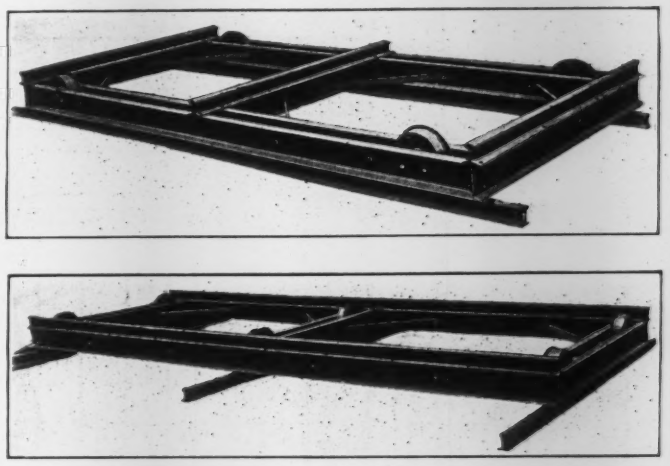


FIG. 5 STANDARD TYPES OF TRANSFER CARS
(Cross-pile type above, end-pile type below.)

stock—ash, maple, elm, poplar and other woods—from 1 in. to 4 in. thick. As body stock averages 2 in. in thickness, the drying time was assumed at eight days per inch, or sixteen days for a grand average of all thicknesses. The averages for thickness and time had previously been tested out carefully. The daily output multiplied by the drying period gave a necessary holding content of 800,000 board feet of lumber in the dry kilns proper.

Other obvious assumptions were loading tracks adjacent to the railroad sidings, holding at least one-half of total kiln charge, green-storage tracks having as much more than a complete kiln charge as possible, and dry-storage rooms holding not less than half a kiln charge. In addition it was necessary to have a heating plant, fuel storage, and a cutting room with a battery of six cut-off saws served by lumber lifts.

Two arrangements are shown, the end pile based on a kiln-car load of 6000 ft. B.M. and the cross-pile based on a kiln-car load of 4000 ft. (see Table 2). Their respective capacities, expressed in board feet, are as follows:

	End Pile (Fig. 6)	Cross-Pile (Fig. 7)
Loading tracks	480,000	368,000
Green storage (before kilning)	1,440,000	1,008,000
Present kiln capacity	864,000	768,000
Future kiln enlargement	576,000	240,000
Dry storage	576,000	1,064,000
Total	3,936,000	3,448,000
Cutting-room dimensions	70 ft. by 110 ft.	180 ft. by 125 ft.

Either yard layout lends itself to the very efficient and economical handling, storing, drying, and cutting of lumber and includes a power house adjacent for the convenient delivery of steam and burning of all mill refuse. A careful study of the storage and three transfer tracks will show that it is possible to store lumber by thickness and width and deliver it as required at the cutting room with a minimum amount of handling.

From the railroad siding along the south side of the yard all lumber is loaded directly on to trucks, and it travels on these through the dry kilns to the cutting room with one handling only.

The lumber yard and dry kilns shown in Figs. 6 and 7 constitute the first-floor plan of three future six-story buildings 100 ft. by 530 ft. paralleling the railroad track, which will have a wood mill and aluminum bumping department on the second floor and the body-in-white and other departments on the remaining floors.

Details regarding types and capacities of kiln cars and transfer cars are presented later in this discussion.

POWER TRANSFER CARS

There is no excuse for the clumsy process of pushing loaded kiln cars or transfer cars by man power. It is expensive at the present cost of common labor, and exhausting and dangerous from the health and safety standpoint. Fig. 8 tells its own story.

The industrial demand has produced a relatively new piece of yard equipment, i.e., an electric or gasoline-driven power transfer car that is not only self-propelling but is supplied with a flexible

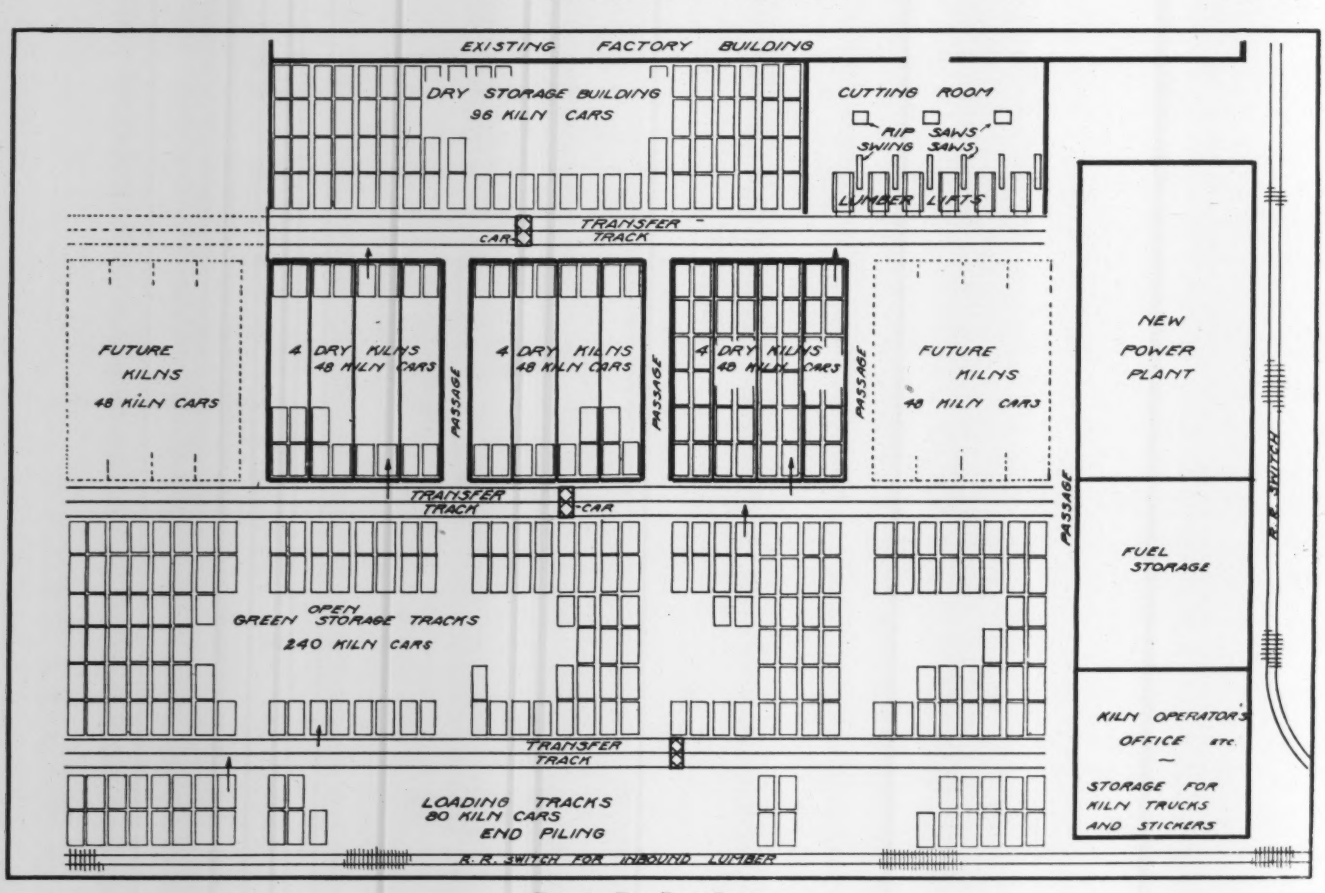


FIG. 6 END-PILE LAYOUT

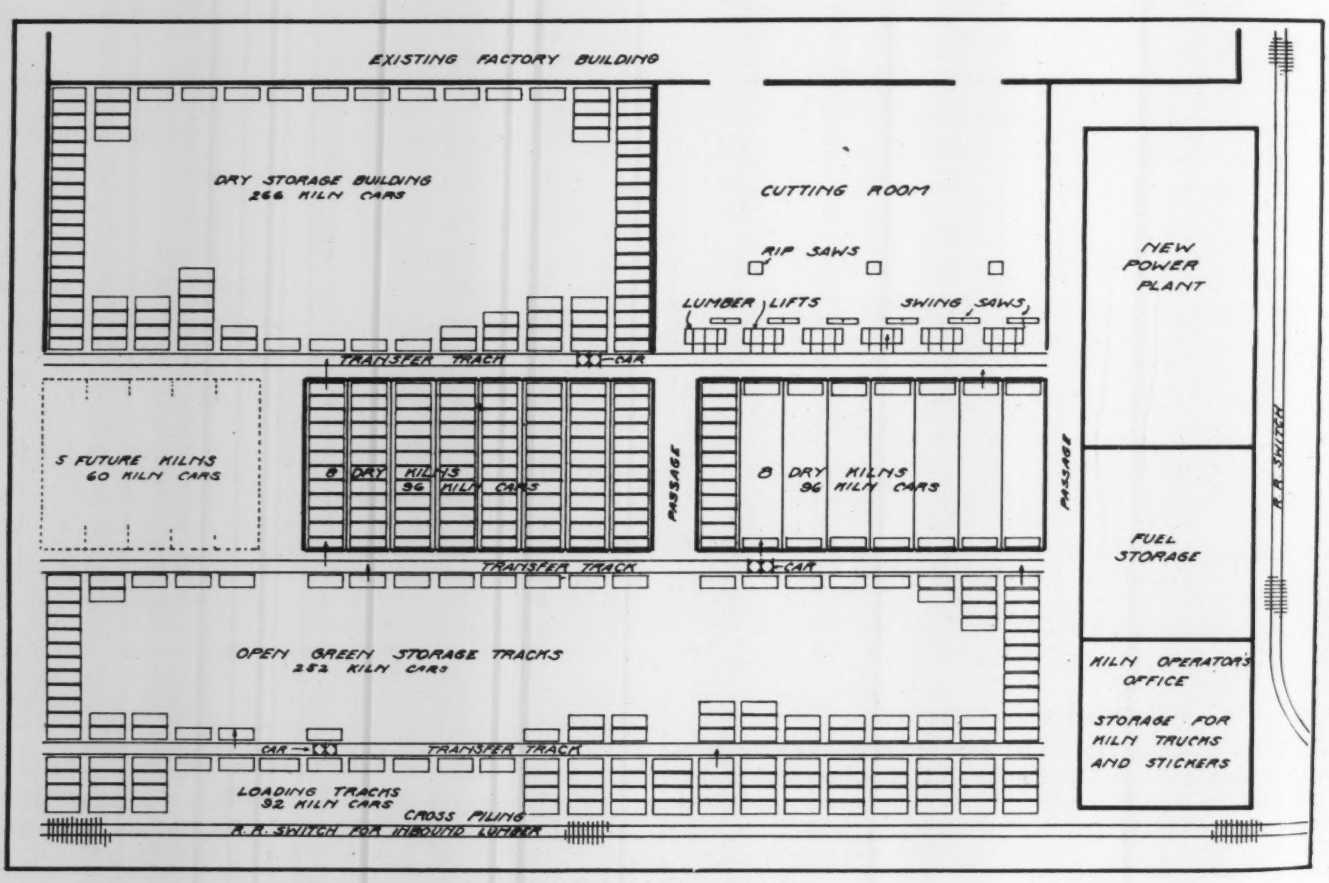
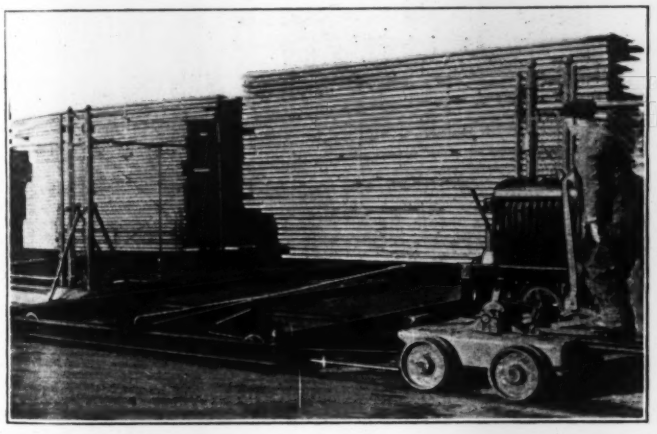


FIG. 7 CROSS-PILE LAYOUT

wire rope and drum and the necessary pulleys or rollers so that kiln cars can be drawn on or pushed off from the transfer car. A combination brake can be provided so that wheels are locked on the

FIG. 8 PUSHING LOADED KILN CARS BY MAN POWER IS NOT ONLY EXPENSIVE BUT EXHAUSTING AND DANGEROUS



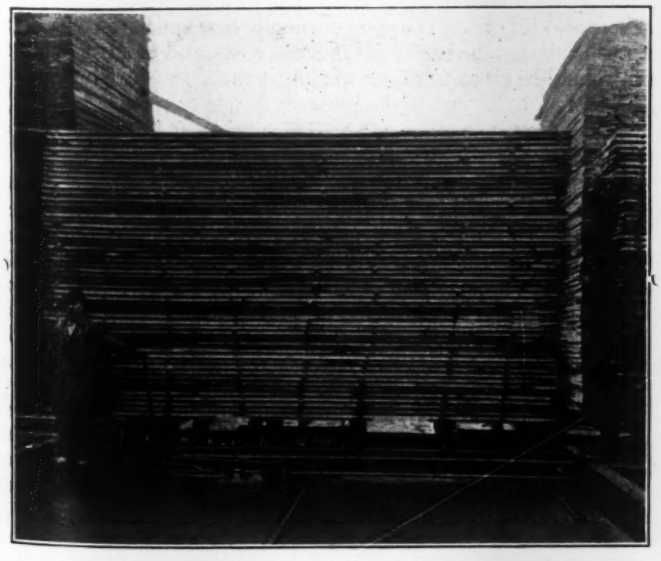


FIG. 9 GASOLINE AND ELECTRIC POWER TRANSFERS

(Above: Empty cross-pile gasoline power transfer drawing on its own load. Below: End-pile electric power transfer ready to travel or discharge its load.)

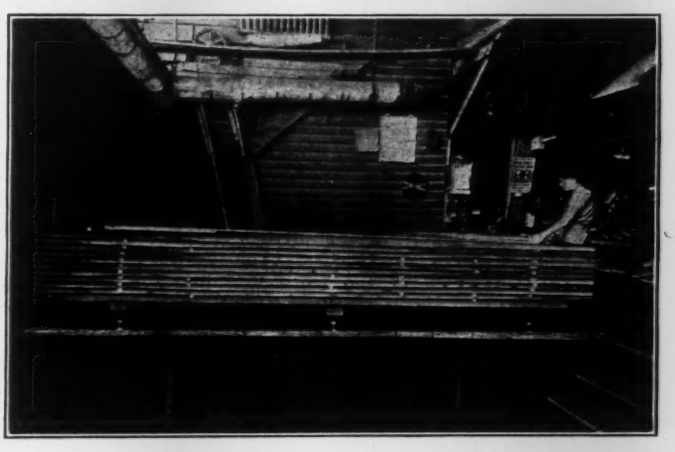
track when operating the drum, or the rope kept taut and the kiln car held in place while the transfer car is traveling. The operator's controls must be reversible and most flexible so that rails can be easily matched and loads not upset. One man, or at most two men, can do twice as much work as six or eight men in the old way shown in Fig. 8.

A number of attempts have been made to adapt standard tractors to this purpose, but the step down into the transfer alley is awkward, and the attachment of a self-winding drum for wire rope complicates the tractor controls. Pushing or "bunting" the loaded cars around is hazardous, and likely to cramp the wheel flanges on the rails unless the push is applied evenly and steadily.

LUMBER LIFTS

This name has been applied to what was originally a quadruple jackscrew (four units operated simultaneously by sprocket chains) for lowering a loaded kiln car into a pit until the top of the load was even with the saw table, and maintaining the top of the load at that level until the kiln trucks were emptied of lumber. Fig. 10 shows the original type, nearly empty, and the improved type from which the unloading has just commenced.

These lifts can be entered from either end or side, by either kiln car or transfer car. The lumber lift is not only adapted for use as an unloading device at a saw, but is equally convenient at a surfacer or other machine. It may also be used to lower a kiln car during the process of loading so as to keep the top of the load at a convenient height for workmen, and also to move loaded kiln cars from floor to floor.



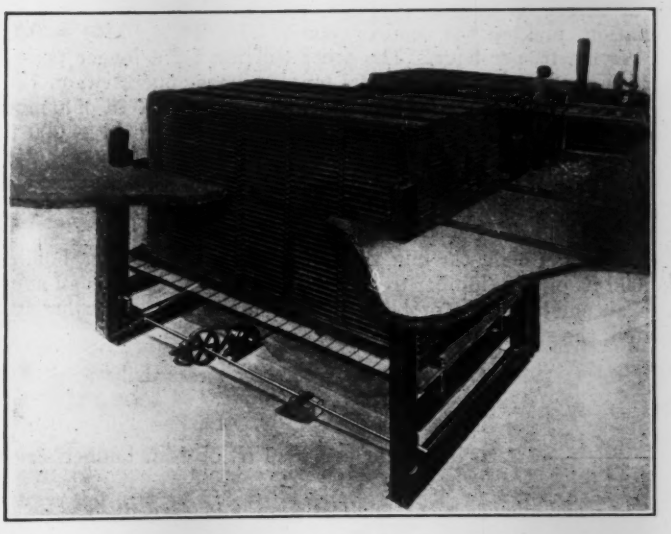


FIG. 10 LUMBER LIFTS

Above: Early type with elevating but non-revolving screws. Requires screw sleeves sunk below pit floor and is limited in range since the four screws may stand unsupported.

Below: Improved type with revolving but non-elevating screws encased at each corner. All drive connections enclosed and running in oil. Can be successfully used for 20-ft. elevations.

Hydraulic types of lifts have been successfully used, but some trouble may be encountered in uneven wear on packing unless the

loads are most carefully centered and balanced. A loaded kiln car is an unwieldly and awkward unit to raise or lower.

The usual counterweighted elevators also have been used for similar service, but the lumber lift requires neither counterweights

TABLE 4 CAPACITY AND ELEVATION OF STANDARD QUADRUPLE-SCREW LUMBER LIFTS

(Based on a consolidation of several types and makes, to meet unusual loads and extreme elevations. Size of lumber load, 6 to 8 ft. wide, 16 ft. long, 10 ft. high above rail. Weights given include motor, controller, and all metal parts.)

Type	Capacity, tons	Elevation, ft.	Screw diam., in.	Weight, lb.
Jackscrew	10	8 or less	3	4200
	8	9	3	4350
	6	10	3	4500
	4	11	3	4750
	20	12 or less	4	7050
	18	13	4	7300
	16	14	4	7550
	14	15	4	7800
	12	16	4	8050
	10	17	4	8300
	8	18	4	8550
Outside Screw	10	10 or less	3	5200
	8	11	3	5300
	6	12	3	5400
	4	13	3	5500
	20	14 or less	4	8300
	18	15	4	8500
	16	16	4	8700
	14	17	4	8950
	12	18	4	9200
	10	19	4	9450
	8	20	4	9700

nor safety brakes and operates at slow speed with a minimum of power demand. The lift installation therefore usually costs considerably less than the regular type of elevator for such heavy loads as kiln cars weighing from ten to twenty tons.

STEAM CONSUMPTION

The steam consumption of batteries of various kinds of dry kilns is not easy to predict, as lumber conditions, climatic variations, and operators' practices give three variables that do not readily reduce to averages. It has usually been contended, however, that 0.2 lb. condensation per square foot of radiation per hour is a safe minimum and that a 25 per cent allowance for steam spray is sufficient, making the steam consumption 0.25 lb. per square foot per hour.

Two recent tests in Grand Rapids at the American Seating Company and the John Widdicomb Furniture Company give substantial proof that the above allowances are ample.

One test ran for 38 days, giving a total condensation of 804,600 lb. or 21,174 lb. daily. The eight kilns contained 9216 sq. ft. of radiation, making the condensation $21{,}174/(24 \times 9216) = 0096$ lb. per sq. ft. per hour. The other test ran for a longer period, resulting in the conclusion that a ten-day drying operation on 1-in. maple required 2500 lb. of steam condensate per 1000 ft. of lu mber dried. Each kiln had 1880 sq. ft. of radiation and held 24,000 ft. of 1-in. lumber. The condensation in this case was $[(2500 \times 24)/(10 \times 24)]/1880 = 0.133$ lb. per sq. ft. per hour. An average of the two values obtained with 25 per cent added for spray would amount to 0.143 lb. steam consumption per sq. ft. per hour.

Assume an eight-car kiln with 1880 sq. ft. of radiation, holding 32,000 ft. of 2-in. lumber to be dried in 16 days, which is an average automobile-body problem. Then, using the unit value just stated, the steam consumption will be

$$1880 \times 0.143 \times 24 = 6452 \text{ lb. steam daily}$$

or

$$\frac{6452 \times 16}{32} = 3226 \text{ lb. steam per 1000 ft. of 2-in. lumber dried.}$$

The usual allowance of 0.25 lb. above would have given

$$\frac{1880 \times 24}{4} = 11{,}280 \text{ lb. steam daily,}$$

or

$$\frac{11{,}280 \times 16}{32} = 5640 \text{ lb. steam per 1000 ft. of 2-in. lumber dried.}$$

A safe figure for the power plant would be a maximum of 5000 lb. of steam per 1000 ft. of lumber dried, and the probable operating basis would be 4000 lb.

LUMBER-YARD STACKERS

There are places in almost every yard where stationary piled lumber is advisable, and it is often convenient to extend these 16-ft. square piles to a greater height than can be conveniently reached. The stacker or piler shown in Fig. 11 answers this requirement and permits piles from 30 to 40 ft. high. Where room is scarce or land valuable, this apparatus will prove useful. Its operation can be reversed for unloading the piles.

There are many other devices that add to the convenience and lower the cost of lumber handling, but enough has been suggested

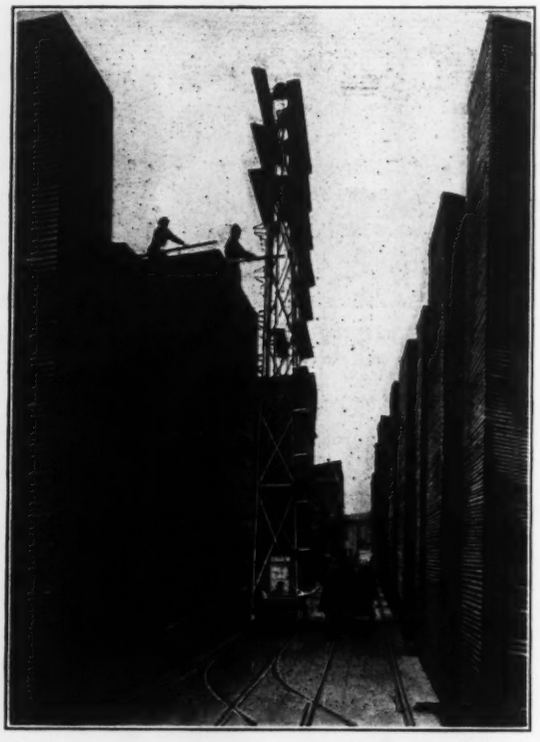


FIG. 11 LUMBER YARD STACKERS

to assist those who have such problems to solve, and to show that the subject is receiving much-needed attention on the part of machinery designers and builders.

There are still plenty of opportunities for new and better apparatus with which to handle lumber at reduced costs, and every encouragement should be given to those working toward its development.

Discussion

W. J. GRAVES[1] in a written discussion said that, having seen several lumber-yard fires and worked to salvage lumber from the flames, the advantage of having storage piles on wheels ready to move quickly had been brought forcefully home to him. In one instance he was convinced that a serious yard fire, which had resulted in a total loss, could have been checked in its early stages, had it been possible to move a few adjacent piles of stock quickly.

As for the personal-injury hazard, it might be stated as a fact that over 50 per cent of the compensation cases now occurring in the wood-working industry arose out of labor in connection with the handling and rehandling of raw stock lumber, the need for which was entirely eliminated by "live" storage and the use of lumber lifts.

Among the most important causes might be mentioned falls from lumber piles, being struck on head or foot by falling plank, and the sliver hazard with its high percentage of serious infection cases. The adoption of the methods mentioned would remove these serious hazards with their consequential money losses, and

[1] Industrial Engineer, Detroit, Mich. Mem. A.S.M.E.

at the same time reduce labor costs and increase the productive efficiency of industrial plants to such an extent that the cost of such installations would be regained in a period of three or four years.

Mr. Nagelvoort, replying to an inquiry made by M. Lund, said that the waste from the stock saws and the rough cutting room was handled by a conveyor underneath the floor, into which the cuttings from the saw tables or machines were dropped. This conveyor took the waste to a storage room or directly to the power house, where it was consumed under the boilers. The object of the layout described in the paper was to get the cutting room adjacent to the power house. In regard to drying lumber, he had made some investigations with respect to reducing the time required for that purpose, and had arrived at the conclusion that considerable time was wasted in the kiln prior to the time when the lumber began to give up its moisture. With the relative humidity in the kiln above 80 per cent, the lumber, he had found, did not give up any of its moisture.

In regard to a question asked by C. M. Wilkinson, Mr. Naglevoort said that neither of the schemes described in the paper had been adopted, but that both of them were practical, the choice being dictated by local conditions. This was also true concerning the use of gas-driven or electric-driven transfer cars.

Mr. Perry called attention to the fact that sawmills could only produce at certain seasons of the year, and that some kind of storage on wheels was absolutely essential in order to reduce the enormous handling costs, which according to various authorities ranged from $1 to $2 per 1000 ft. per handling. As to the difference between end piling and cross-piling, the authors had found that satisfactory drying could be obtained employing either method. However, where there was much dimension stock or odd-size lumber, end piling worked into smaller units and made a more efficient use of the lumber-drying space in the kiln. Ventilation was also slightly better in the case of end piling, there being somewhat more of the load adjacent to the air-circulation aisles.

J. A. Shepard,[1] who presided over the latter half of the session, said that on the Pacific Coast, where the mechanical handling of lumber was carried to a high degree of refinement, he had seen cars in dry kilns operated by longitudinal and cross cable systems to which the cars were gripped. Referring to the cost of $1 to $2 for each handling of the lumber, he wondered whether it included the burden charge of from 50 to 100 per cent usual under factory conditions.

Replying to Mr. Shepard, Mr. Nagelvoort said that his company paid a piece-work rate of $1 per 1000 ft. for handling lumber, overhead not being taken into consideration. Mr. Perry supplemented Mr. Nagelvoort's statement by saying that the Plywood Association, of which his company was a member, had considered the matter and had decided that in the case of lumber movement in the yard they would not apply the general overhead charge but would include the yard overhead, which was much smaller than the factory overhead, in the cost of the lumber.

Evaluating the Cost Department

Varying Views of Cost Accountants, Engineers, and Others on the Possibility of Measuring the Cost-Accounting Function

IN A PAPER on the Measurement of Management presented simultaneously at the Chattanooga Regional Meeting of the A.S.M.E. and at a joint meeting of interested societies in New York on October 23 last, the author, Prof. J. W. Roe, outlined the problem and suggested a method for comparing managerial performance in different plants—or of variations thereof in different plants—that he believed would be trustworthy, practically useful, and as free as possible from the element of personal opinion. In dealing with the element cost accounting, however, Professor Roe stated that he had been unable to discover a standard or means of measuring performance in it which would be satisfactory or generally applicable; and that the best way would be to recognize this frankly, set up an ideal, and rate the performance of the management in this element on the basis of judgment of men properly qualified to pass on it.

With the view of obtaining a general expression of opinion on the possibility of measuring the cost-accounting function, the Executive Committee of the Management Division arranged for a discussion of the topic at the session on the Measurement of Management at the A.S.M.E. Spring Meeting, Cleveland, held on May 28, and invited a number of engineers, accountants, comptrollers, and others intimately acquainted with the workings of cost departments to submit their ideas on the subject. Communications were received from Messrs. L. M. Lamb, G. Charter Harrison, John M. Scanlan, S. C. Allyn, W. O. Cutter, and N. M. Cartmell. These, slightly abridged, together with extracts from discussions submitted from the floor, immediately follow.

L. M. LAMB.[1] Professor Roe hits the nail on the head when he says that the best way would be to set up an ideal and then rate the performance of the management in cost accounting on the basis of judgment of men properly qualified to pass on it. For example, it ought to be a comparatively easy matter for some one familiar with conditions to know when various kinds of operations should be completed each month and developed into the final statement. If it is out on time, all well and good. If not, what is the matter? What good is it to know that we are one per cent less efficient this month than last? I am of the opinion that it is impractical to attempt an evaluation, even though formulas could be worked out for that purpose.

G. CHARTER HARRISON.[2] A cost system, like any other business instrument, must be judged primarily by its effect on the profit- and loss-statement—in other words, it is of value only to the extent to which it aids in the making or safeguarding of profits. The prime value of a cost system considered from this standpoint is in pointing out to the manufacturer where the profits which he should, but does not, earn are going to.

To arrive at any exact valuation of the benefit of a cost system to a business is like attempting to appraise in dollars and cents the value of a compass to an Atlantic liner. It may mean all the difference between safety and a total wreck. It depends very largely upon conditions; a cost system, the scope of which is confined merely to determining what things cost, and which ignores the efficiency factor, may cost more to operate than the results it produces are worth, particularly in a business where the selling prices are based upon what competitors are charging rather than on what the cost records show.

The results which can be obtained from a properly devised and operated cost system may be worth many, many times what the cost system costs to operate. In a recent case the writer investigated the condition of a business that had no cost system, and the report of a competent engineer proved conclusively that the factory in question was not operating at over fifty per cent efficiency, whereas the proprietor was under the general impression that the factory was producing economically. In that business a well-designed standard cost system would have forced improvements which would have resulted in savings of considerably more than a hundred thousand dollars a year at a clerical cost of probably not more than ten thousand dollars a year. The value of a cost system to that business might conservatively be figured at half a million dollars.

[1] Comptroller, Greenfield Tap and Die Corporation, Greenfield, Mass.

[1] Vice-Pres. and Ch. Engr., Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. Mem. A.S.M.E.

[2] G. Charter Harrison Associates, New York, N. Y. Assoc-Mem. A.S.M.E.

BENEFITS TO BE DERIVED FROM THE OPERATION OF AN ADEQUATE COST SYSTEM

Unfortunately, cost accountants have not as a whole realized that the profit-making and profit-saving functions of a cost system are all that make it economically worth while. An illustration of this is the statement made recently by a well-known cost accountant to the effect that there were three primary benefits to be realized from the operation of an adequate cost system: namely,

1 The establishment of correct selling prices which eliminate the uncertainty of whether the product is being sold at a profit or a loss
2 The concentration of salesmen on sales of more profitable articles
3 The concentration of manufacture on the more profitable articles.

There is, of course, no question as to the importance of the first of the results enumerated, but the implication that the real secret of business success lies along the line of taking the profitable business and leaving the unprofitable to competitors outside of highly restricted limits is impracticable. If all manufacturers adopted this policy the competition for the abnormally profitable articles obviously would soon reduce the profits on these to a point where they would no longer be especially remunerative. It is apparently assumed that a cost system is only of value when it is a monopoly. The real value of a cost system is not along the line suggested of taking advantage of the ignorance of competitors, but in drawing attention to our own inefficiencies so that these can be eliminated. Cost accounting along these lines is of inestimable value; it may, as I have previously stated, mean all the difference between prosperity and bankruptcy.

JOHN M. SCANLON.[1] The scope of accounting has greatly broadened during the past five years. Instead of confining its efforts to furnishing the cold historical figures, data are now secured which aid materially in cost reduction. The cost department, among other things, does the following:

1 Determines, from data furnished by the time-study department, the efficiency of employees
2 Aids materially in controlling material
3 Points out to the operating department where excessive costs are occurring
4 Compares actual costs with standard costs and explains the difference between actual and standard figures
5 Predetermines the cost of work to be done.

I believe, therefore, that the value of a cost system can be measured equally as well, if not better, than some of the departments mentioned by Professor Roe in his paper last year.

S. C. ALLYN.[2] The measurement of the results of a cost department could be reduced to a formula but it would be largely theoretical. I question whether the practical application of it would be worth the labor involved, and the formula would necessarily have to be largely the judgment of some one individual. There are so many factors beyond the control of the cost department that it would be difficult to create a definite standard and formula to measure efficiency.

RESULTS TO BE EXPECTED FROM A COST DEPARTMENT

In our industry we expect certain results from our cost department: namely,

1 Data pertaining to factory efficiency
2 Standard costs of parts, assemblies, and machines
3 Current costs of parts, assemblies, and machines
4 Actual costs and their relation to standard costs
5 Promptness in furnishing the results
6 Tie-up with the general books.

The actual cost of each individual job in an industry which is manufacturing tens of thousands of small parts and repeating the orders constantly, is not the essential thing. If the standard cost of each part is determined and the efficiency of each department as compared to standard can be determined, then the actual cost can be obtained by applying a ratio. We are more interested in knowing the efficiency of each department and the individuals in the department. For example, we are more interested in knowing how much at standard labor prices a workman turned out during the day and the relation between his actual wages to standard than in how much time he spent on any particular job.

The viewpoint of cost accounting must be changed to a prospective one rather than a retrospective one. Current costs are more important than past costs, which are more or less historical. A cost system in the future must be able to project costs with a certain degree of accuracy.

The best basis of measuring management in my opinion is through the setting of standards and budgetary control. The monthly statements of actual results as compared with the budgets reveal the efficiency of management.

Through this method the management is compelled to consider all phases of the business before an expense is incurred or a new policy is put into operation. The accounting records then become more valuable as they show what has been obtained as compared with what was expected to be attained. They show up the variations from standards, the very thing in which the management is most interested. Cost accounting as well as all other accounting has dealt too much with past results and has not kept pace with other functions of the business which are constantly looking into the future, such as the selling and manufacturing divisions.

What the manufacturer needs today is better results at less expense. The work of the average cost system is still costly and burdensome. The problem before too many manufacturers today is the high cost of cost accounting as compared with the results obtained.

W. O. CUTTER.[1] In an industry where the bulk of production covers special work undertaken on an estimated price, the cost department's greatest value would be in its ability to predetermine costs for the purpose of setting selling prices and to furnish such information as would preclude any possibility of loss occasioned by the improper or inefficient use of material or labor. In an industry manufacturing a line of product on which prices are more or less fixed and do not vary directly with the actual cost from month to month, its value would be in establishing basic figures that would act as guides to improved efficiency and lower costs in the use of materials (reduction in scrap losses, etc.); savings in direct labor by improved methods, by routing the production and introducing labor-saving devices; and savings in overhead through constant check of expenditures for the various classes of expense. In this second instance the simplest and most efficient method of supplying cost information would be by setting standards for each element of cost, further subdividing the three major divisions into as many standards as would be of assistance to the interested principals, and arranging to submit either daily, weekly, or monthly the actual performance against such predetermined standards. By carrying such comparisons currently, it should be possible to apply the remedy where necessary if costs are not running as near standard performance as they should.

In both types of industries mentioned above a measure of efficiency and value for the cost department can be determined in regard to the accuracy and promptness of their information. Accuracy and promptness cannot be measured by a general standard applicable in all cases, but specific jobs can be classified in a number of groupings for which standards can be established.

COST DEPARTMENT SHOULD BE EVALUATED LARGELY ON BASIS OF COST OF COST INFORMATION

In every industry, however, the cost department should be evaluated largely on the basis of cost of cost information, as no value whatever can properly be placed on the advantages of accurate figures or the promptness of reports submitted if such accuracy and promptness are secured at a cost that is excessive.

There are two separate angles to this question of a cost department: first, is the cost department operating as efficiently as it should, or, in other words, has the same line of reasoning that might be applied to manufacturing operations or processes by the cost department for the reduction of costs been applied to the routine methods of cost work?

The second is a larger question, as to exposure and what it costs

[1] The Hess-Bright Mfg. Co., Philadelphia, Pa.
[2] Comptroller, The National Cash Register Co., Dayton, O.

[1] Comptroller, United States Rubber Co., New York, N. Y.

to secure what might be considered cost insurance. If by some very simple control figures we can secure information as to costs that might be accurate to within one or two per cent, it is quite obvious that it would not be good business to spend a sum of money for more detailed information that might reduce this error one-half of one per cent when we sum up at the end of the year and find this additional information has cost us more than the amount of money represented by the additional saving.

In conclusion, therefore, it can be said that no standard or means of measuring performance in the cost department can be established which would be satisfactory or generally applicable for it as a whole in all industries, but that individual standards for specific performances can be established and a measure of cost can be determined in order to show the value derived from the department.

N. M. CARTMELL.[1] The writer agrees with the statement of the function of a cost department, but would add a third measure of the efficiency of the cost department: namely, (*c*) How costly are the methods of securing this information? Furthermore he believes that no separation should be made between the cost department and the general accounting department when determining a method of evaluating efficiency, because their functions, methods, routines, and schedules are too closely related and interdependent; in fact, the two will be one department in small organizations.

(*a*) Standards can be and are being used for evaluating the accuracy of the accounting function. In each case 100 per cent accuracy should be the aim for each routine (payroll, labor distribution, etc.), even though it is recognized beforehand that some errors will be made, as in payroll compilation. Reasonable checks for accuracy should be established for each routine, and penalties established of a definite value of so many points for each error found in a final report or record.

(*b*) Definite dates can be established for completing every routine of the accounting function—for instance, payrolls must always be ready by a certain time. In most plants under 500 workers, job costs should be compiled in four working days after the completion of the order; departmental overheads, etc., in five working days; and the profit-and-loss statement and balance sheet in eight working days. Special and unusual conditions may lengthen this period in some plants. Plants of 1500 workers require approximately one-third additional time, and some large organizations with plants scattered over the country will require longer periods. Deviations from these schedule dates can be evaluated in penalty points similarly to the evaluating of errors in (*a*).

(*c*) Four plants out of five getting much detail cost and accounting information are spending too much money to secure it. Fewer reports will insure greater action for those retained. Shorter methods almost invariably will retain all reasonable fineness and accuracy in timekeeping, costs, etc.

The number of general-accounting clerks and all executives will change very little as business volume fluctuates between the limits of the business cycle. Timekeepers and similar clerks should fluctuate in numbers as workers, maintaining an approximate ratio of 1 to 20 or 1 to 75 as methods and conditions in each individual plant require. Measuring the quantity of cards which is handled by tabulating-machine cost clerks is a well-recognized example.

Keeping the accounting expense within reasonable bounds must be recognized as important. Ratios of cost clerks to workers must be held; otherwise, reports may be prompt and accurate only because of excessive clerk hire.

A PROPOSED POINT-SYSTEM FORMULA

To summarize, the writer does not believe that all accounting activities can be worked into one percentage formula, even of the type Professor Roe suggested for the purchasing function. If each individual accounting activity were to be evaluated on an individual-percentage formula basis, each resulting percentage would require weighting according to its importance before compiling a general percentage of efficiency; hence the writer suggests establishing by judgment a quota of good points, say, 1000 points per month. Evaluate each failure at so many points according to importance, and use this formula: 1000 points less the total penalties for errors and failures, divided by 1000 possible points, equals the operating ratio of efficiency.

F. B. Gilbreth,[1] who opened the oral discussion, said that he saw no difficulty in measuring the efficiency of a cost department. Any operation could be measured provided one decided on the units to measure and equipped himself with methods of measuring and proper devices to make the cost of measuring cheap. Cost departments in nearly all cases lost sight of the fact that costs should be furnished to an executive promptly so that he could compare them day after day with the preliminary estimates. If they did not do this, they were not properly functioning. He suggested as units to employ (1) the number of minutes late, as compared with the standard, that the information reached the executive, and (2) the amount of the cost reported as compared with that predicted.

J. A. Shepard[2] said that a variety of tasks were being placed on the cost-accounting department that did not belong there. The cost accountant should properly be expected to determine the costs of things that were done—his function pertained to events that had happened. The management of a business might determine the appliances that were to be used for a new product, in which case, how could the cost department predict a cost? He wished to make a plea that the cost department deal only with the actual costs, and the management or the engineer with prospective costs.

Robert T. Kent,[3] who presided over the session, said it seemed inconceivable to him that an activity that could be compared with something could not be measured. If engineers were to take control of industry they would have to find some way of measuring every function of industry. Mr. Shepard's point, he believed, was very well taken. In that connection Mr. Kent cited one of the most efficiently managed plants in the country where he thought the efficiency of the cost department as a cost department was practically zero. The manufacturing end of that plant knew how to set the tasks and what the labor costs would be on every job. It had provided means whereby the labor costs should not be exceeded and knew what its material costs would be; and when a job was completed it knew its labor and material costs, and these plus a certain percentage of overhead for a given period, provided it with the total cost. The actual costs as furnished by the cost department, however, were about three months late. Nevertheless the manufacturing department was kept up to a high plane of efficiency, because it measured costs in things that did not change—pounds of metal, minutes of time, etc.; it knew what those things should be and took steps to see that they were kept within the limits set.

THE three fundamental stages in a system of cost recording suitably concentrated to meet the requirements of a small organization consist of: (1) Recording daily costs on customers' orders as they pass through manufacture; (2) summarizing these daily costs into totals for each customer's order when the latter has passed through manufacture; and (3) at the end of the month, preparing from the summarized cost sheets whatever statements or graphs are necessary adequately to visualize each month's performance. There still remains a fourth stage, which might be described as *the interpretation by small-factory management of the cost data submitted by the small-factory planning office.*

The three important media from which the small-factory manager must draw his conclusions and formulate his future policy are undoubtedly the cost analysis of completed orders, the monthly statement of profit and loss, and the Gantt monthly idleness chart. Of these three the cost analysis possesses, perhaps, greatest utility, because it throws into relief the comparative economic value of different lines of product and indicates which of these, if any, should be discarded. (From Recording Job Costs to Show Profits, by Geoffrey C. Brown, in *Management and Administration*, vol. 8, no. 1, July, 1924, pp. 53–57).

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[2] Vice-Pres. and Ch. Engr., Shepard Elec. Crane & Hoist Co., Montour Falls, N. Y. Mem. A.S.M.E.

[3] Montclair, N. J. Mem. A.S.M.E.

Economic Analysis of Machining Operations

Discussion of DeLeeuw Paper Elicits Valuable Supplementary Information

AT THE session on Tooling and Gaging for Interchangeable Manufacture held on May 29 at the A.S.M.E. Spring Meeting in Cleveland, in which the Machine Shop Practice and Ordnance Divisions of the Society coöperated, a paper was presented by A. L. DeLeeuw entitled Analysis of a Machine-Shop Problem on a Quantity and Final-Economy Basis. This paper, which was published in the June issue of MECHANICAL ENGINEERING (p. 335), discussed the nature of the analysis which should be followed in determining the most economical method of machining work, either in large or small quantities, called attention to the difference between the saving of labor cost and the ultimate economy, and gave examples of comparative analysis dealing with the various machining operations required on a certain automobile part when made in quantities ranging from 100 to an unlimited number. The discussion, which brought out much valuable supplementary information, appears in extended abstract below.

E. J. Bryant[1] contributed a written discussion in which he stated that the paper pointed out the necessity of a very careful analysis of all of the elements entering into the cost of special apparatus before determining on making an investment, particularly depreciation and interest on investments, which were frequently overlooked. On the other hand, there were several factors in favor of special equipment such as the reduction of the amount of the supervision and incidental loss of time due to the looking after of the several individual operations and frequently the supervision of a larger number of employees with the necessity of breaking in and training of new men to perform the required work, and the usual gain in the accuracy of the parts produced.

It would seem that in the case cited by the author one of the fundamental principles in automatic machine designing had not been followed out, namely, the dividing of the operation in such a way that the time consumed at each station would be substantially the same. In this instance without doubt it would not be practical to split the milling operation which was done in 30 seconds, but evidently the other operations could be factored so that the output of the machine would have been figured on a 30-second basis instead of on a 100-second basis. Undoubtedly this would have added somewhat to the cost of the machine, but on the other hand the increase in production by such a high percentage would probably more than offset the increase in cost necessary.

Mr. Bryant realized that the principle involved in cost analysis was what the author was driving at, and of course the number of parts that were ultimately required from the machine was really the controlling factor. It was useless to figure on designing a machine to turn out 100,000 parts in five years if the largest probable number required would be only 10,000. He knew from experience that many jobs that looked as though they could be produced at a material reduction by utilizing special equipment did not show a profit on a money investment when a complete analysis of the number of parts required in a given period, which was likely to be the life of the product in question, was made.

R. H. Rausch,[2] in opening the oral discussion, cited instances of his own knowledge that corroborated the author's arguments for the study of machining operations from a final-economy basis. As in many cases special machines would not always be in operation, he believed that the question of idle time should be considered in connection with the economy basis.

Maj. Earl McFarland[3] said that it had been found at the Springfield Armory that the extra cost of a special machine over that of a standard machine was many times paid for by a very slight saving in productive cost over a long period of production.

John Younger[4] cited the practice of the London General Omnibus Co. in the repair or replacement of parts at specified intervals as an example of foresight worthy of consideration with respect to both standard and special machines.

Ralph E. Flanders[1] said that the author's statement that a special machine should be sufficiently flexible in the matter of hole distances to accommodate other pieces of the same general nature as that for which it was designed, was highly important. He had seen special machines which were so completely tied up to a given design that when the piece was changed to a slight extent a very large investment was rendered nearly useless.

As Mr. Flanders saw it, there were three kinds of shop equipment for making parts: the standard machine, lending itself to comparatively simple operations and a large subdivision of the operations, dividing the total cost into a large number of sections; the completely special machine, doing all possible at one setting; and the intermediate type of standard machine designed with the idea of its being a framework on which highly specialized tooling might be placed for more or less complicated operations. There were a number of machines in the latter type in use in the automobile industry today, which, while they provided a range of pieces, yet lent themselves to highly specialized tooling which converted them practically into special machines for that piece. That was a very good solution of the problem of standard or special machines in many cases, because while a special machine of a new design might break down and seriously interrupt production and was incapable of progressive development or improvement in use, yet highly specialized tooling was capable of change and development right in the midst of production without interrupting it. Often a proper compromise was reached by using a standard machine developed with the idea of highly specialized tooling in mind.

Taking up a specific case, Mr. Flanders said that his firm built turret lathes with headstocks. The headstock had to have a number of holes bored through it at accurate distances and with accurate parallelism and accurate size for the shafts and spindles. That presupposed the necessity for an accurate and expensive jig. The natural thing to do would be to fasten such a jig on the bed of a high-grade boring machine, the boring machine having means for shifting the spindle opposite the various holes in the jig and boring the holes through one after the other. Another thing that could be done, however, would be to recognize the fact that the jig was accurate and that there was no necessity for an accurate machine to go with it. All that was needed was some means of revolving the boring bar, with sufficient power and a fair degree of steadiness in the drive. This could be met by a very cheap and rough mechanism that could be built to drive four, five, or six boring bars at once. The result was that if such a special boring machine was designed for the jig and the boring machine and jig formed one mechanism, the total cost would be very much less than that of the jig and a standard boring machine and the special machine would get out the work in from a third to a fifth of the time, depending on the number of spindles, and would be a mechanism that a concern could well afford to have stand idle whatever part of the time was necessary.

About twenty-five years ago, Mr. Flanders stated, he had paid a visit to the Waltham watch works. At that time the Waltham and the Elgin were the two leading watch-making companies of the country and were working on two entirely different schemes of automatic machinery. The Elgin plant was using highly complicated and expensive turret station types of machinery in which all the operations, for example, on watch plates, were grouped on one machine and the parts were moved around from one station to another. At the Waltham plant, on the other hand, the watch plates were made on a series of a dozen or more machines, one for each operation, stretched out along a bench with transfer arms running from one of the simple machines to another and a reservoir between each two machines. The total investment was very much smaller, and reservoirs made it possible to stop one element if the

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[3] Commanding Officer, Springfield Armory, Springfield, Mass. Mem. A.S.M.E.

[4] Editor and Publisher, *Automotive Abstracts*, Cleveland, O. Mem. A.S.M.E.

[1] Mgr., Jones & Lamson Machine Co., Springfield, Vt. Mem. A.S.M.E.

tools needed changing or if sizes needed adjusting or in the case of a short breakdown while the others went right on. He understood the Waltham works had since adopted the turret-type plant and he had heard rumors that it had not proved as successful as the earlier scheme of the comparatively simple machines with the automatic transfer.

A. J. Baker,[1] who presided over the session, referring to conditions in automobile manufacturing plants, said that it was by no means uncommon to see machines of standard type laboriously working away, wasting a large percentage of the operator's time in idle, non-productive moments. Such machines not being equipped with any conveying mechanism, the work would pile up around them and have to be picked up and carried away time after time. The size and number of machines made it impossible sometimes for any fixed lines of work to pass through from one group to another, because one machine was so efficient in performance that it occupied a very small space, whereas the next operation was taken care of by a battery of machines so that there were perhaps ten lines converging to one machine for one operation and only one line to the other, with the consequence that traffic congested. That was a serious state of affairs in a large plant handling relatively large pieces. With reduced production—a smaller number of parts going through the factory—the overhead increased and it was more important that the lines of progress of the work should be maintained clearly than it was when full production was going on. The reason of that was self-evident; it was a cost proposition.

Another thing rather badly planned in many automobile plants was the complete lack of balance in tooling equipment. There was no reason why the major parts of tool equipment should not be in duplicate or triplicate or kept for replacement. If a duplication of small parts, a duplication of tooling, a duplication of any vital element that would cause a serious breakdown could be accurately calculated it would, Mr. Baker believed, largely facilitate the use of special machines or make their use more attractive.

The author, Mr. DeLeeuw, supplemented his paper by giving two examples of specialized equipment, the first being that of an entirely specialized machine, that justified its existence by the product, or rather the profit, it gave. This was a machine which performed a certain number of operations on the bedplate of a Singer sewing machine, family type. On that bedplate there were 78 distinct operations—milling, threading, reaming, tapping, facing, boring, etc. First, the top surface was milled in an ordinary old-time Lincoln miller. The second operation was the milling of the round on the corners. After that one milling cut was taken which could not be reached in any other way, then a small groove was cut on top of the plate and inside of that groove the next operation stamped the number of the machine. Altogether there were five operations. The piece then went to a machine of the driller type where it was clamped and the remaining 73 operations were done in half a minute. To do 73 operations of any kind, however simple, in that time was almost prima facie evidence that the machine was economical.

Mr. DeLeeuw had in mind also a number of other machines, small milling machines, grinding machines, etc., which were simply tooled up especially for certain operations. These machines were of the simplest kind and the cost of the tooling might be as much as the cost of the machine itself. Where there was a fair expectation that the life of the piece to be made would extend over a number of years, it was not only reasonable to have a special machine particularly designed for that particular piece with that particular design so that nothing could be changed without overhauling the machine, but it was even reasonable to have that special equipment stand idle part of the time. For instance, in the sewing-machine business there were certain types for which the demand was more or less seasonal. This might be taken care of by running all the year on a particular machine and during the slack periods piling up stock, but when one began to figure out (and here was a part of the economy of shop operations on which Mr. DeLeeuw said he had not touched in the paper) the amount of floor space required, the amount of handling, and the amount of money tied up in finished material and labor, then it would be found that there was much less tied up when the floor space was simply left occupied by the machinery and the machinery itself stood idle for a few months.

This idea had been carried out at the Springfield Arsenal and occasionally at large manufacturing plants, for instance, at the Singer Manufacturing Company. That company gave perhaps the best example he had ever seen of all the different quantities of production. Some of their sewing machines were manufactured in hundreds of thousands a year, others at the rate of one or two a year; others at the rate of one hundred, and still others at the rate of possibly ten thousand, and all kinds of arrangements had to be considered. In addition to having the strictly specially designed machine for a single piece, they also used a large number of machines which were suitable for a number of peculiar operations. There were so many ways in which special machines could be arranged that it was not possible to give a general rule in this respect, and for that reason he had tried to bring out the necessity of analyzing each problem on its own merits.

In regard to the systems of making watch parts which Mr. Flanders had mentioned, Mr. DeLeeuw believed that the system used at Waltham would be the ideal one, even without the transfer arms, so long as the operation had not settled down to absolute constancy. Whether the piece was transferred by a unit agency or by mechanical means from one operation to another, every transfer meant the possibility of an additional error. A special machine which did all the operations also had its errors, but these were component and always the same, at least they remained the same for a certain length of time. These errors could be discovered and corrected, but with a combination of errors which were caused at various places it would be very difficult in the first place to see exactly why or where the error had occurred, and, in the second place, when one had been corrected another might spring up again and make it necessary to consider the same problem all over again. For that reason he would say that when one was sure of conditions the station type of machine was preferable to the transfer type, and vice versa.

One reason why the station type of machine was in favor with those using special machinery was that there was a minimum of chucking to be done, which meant, first, a minimum of manual labor and therefore a reduction in labor cost, and second, a minimum of accumulation of errors. There were a number of pieces used, however, which could not be treated that way because it was not possible to grip the piece in such a way that all of the operations could be done, but he had overcome that problem by the simple expedient of doing the cutting off last.

The economy of not having to store goods in process, said Mr. De Leeuw, was brought to his attention very vividly not very long ago. A certain shop which consulted him frequently did practically nothing but presswork. One of the pieces which they made in large quantities required nine operations, and the operations were done singly, which of course meant that all the dies were of simple construction. On his advice they combined all nine of the operations. The main advantage was not in the saving of the labor cost of eight or nine operations but in the fact that heretofore after the first operation they had had to haul away an enormous amount of steel stock and place it somewhere until the next press would be available. Then they had to haul it back again to this press and haul it away once more for the third operation. So they had eight double haulings to do, sixteen handlings of big piles of material. It was very seldom that a press was available for the next operation immediately after the previous one had been completed, and they had to allow themselves not less than six weeks between the first and last operation in order to be sure of their deliveries.

The main advantage in the complicated die they were now using was that five minutes after they began to manufacture they had sufficient finished material to begin to assemble. In other words, there was absolutely no money lost on account of the keeping of inventories.

[1] Ch. Engr., Willys-Overland Co., Toledo, O. Mem. A.S.M.E.

Erratum

IN THE description of the Rockwell hardness test on page 361 of the June issue, the minor load mentioned in the second line of the right-hand column should read 10 kg. instead of 60 kg.

Education and Training for the Industries

Investigation into the Character and Extent of Such Training—Making Industry Attractive to High School and College Graduates—Labor as a Means of Social Salvation

THE Conference under the auspices of the Committee on Education and Training for the Industries, which was held in Cleveland, May 28, as a feature of the A.S.M.E. Spring Meeting, reflected considerable interest in this subject on the part of the small but representative group present. The attendance suffered on account of an unusually attractive technical meeting scheduled for the same hour. Both industry and education were well represented by the thirty-odd persons present, and the reports which were presented and the discussions which followed occupied an entire afternoon.

Chairman John T. Faig, President of Ohio Mechanics' Institute, Cincinnati, Ohio, reported preliminary progress in line with the resolution passed at the Committee's conference at the New York Meeting on December 5, 1923, as follows:

> *Resolved:* That this conference requests the A.S.M.E. Committee on Education and Training for the Industries to prepare a plan for a careful study of the character and extent of the education and training of non-college types, which will be most serviceable to the industries and society interested.

The Committee has prepared a data sheet for recording the principal features of courses in industrial education, and is sending copies of it to a considerable number of selected cases. It is expected that the replies, of which over one hundred had been received at the time of the Conference, will give an idea of the variety of the courses offered throughout this country, their content, and the agencies through which they will be conducted. In the light of this information the Committee hopes to continue this preliminary examination of the problem of how a plan for the more comprehensive study implied in the resolution just mentioned may best be formulated. The replies already received, which relate to only a small portion of all of the existent instances, clearly indicate that there is great and widespread interest in this subject, and that there is very great variety in the types and content of the courses offered. The Committee is proceeding slowly, partly because of the very limited means at its command, and partly owing to the magnitude and difficulty of the undertaking and the necessity for extended preliminary consideration. S. S. Edmands, of Pratt Institute, a member of the Committee, presented to the Conference a brief discussion of a suggestion that the Committee's investigation of courses be confined at first to shop and corporation schools, which suggestion was apparently received favorably by the Conference, and is to be considered by the Committee at an early date.

Dean R. L. Sackett, of the School of Engineering, Pennsylvania State College, presented a paper entitled Making Industry Attractive to High-School and College Graduates, and President Ira N. Hollis, Worcester Polytechnic Institute, delivered an address on Labor as a Means of Social Salvation, which was of an inspiring character and was well received. Both of these contributions are published below.

L. D. Burlingame, industrial superintendent, Brown & Sharpe Manufacturing Co., Providence, R. I., gave a brief account of that company's system of apprentice training, after which Franklin T. Jones, supervisor of training, The White Motor Co., Cleveland, Ohio, pointed out the importance of a proper attitude of youth toward labor, and discussed the influences which determine this. There then followed a general discussion on education and training for the industries, which was participated in by Messrs. Myron J. Jones, B. F. Goodrich Rubber Co., Akron, Ohio; Oliver B. Zimmerman, assistant to manager, Engineering Dept., International Harvester Co., Chicago, Ill.; John G. Matthews, former senior instructor in machine design, E. Technical High School, Cleveland, Ohio; A. L. Williston, formerly director, Wentworth Institute, Boston, Mass.; Maj. Frank B. Gilbreth, consulting engineer; Frank E. Sanborn, formerly professor of industrial arts, Ohio State University; and L. W. Gill, principal, Hamilton Technical Institute, Hamilton, Ont.

Making Industry Attractive to High-School and College Students

BY R. L. SACKETT, STATE COLLEGE, PA.

I REFER to the problem of making the productive side of industry and transportation more attractive to high-school and college graduates and to those who have left either school before graduating.

The high-school student has become accustomed to methods of learning as practiced in our schools. If he enters industry he believes that most of that training is wasted. He knows that in most industries he goes to work and must produce at once. He knows that the methods by which he learns now are different from those by which he has learned much that he knows. All industries take young men and women who have had little training and give them a start in their business. Comparatively few capitalize the methods of learning which the schoolboy knows.

Those firms which have well-organized training courses or "sandwich" courses where the young employee learns and then applies what he has learned, have found it more efficient than the old method of learning by doing and misdoing and also as attracting a more desirable type of person. This applies not only to "white collar" jobs but also to those who are selected for toolmakers and other mechanics, to stock-room and shipping boys. Carefully-worked-up courses of instruction are now practically standard and should be more widely employed.

The old apprentice courses for carpenters, mechanics, millwrights, and others were four years in length. Times, methods, and the qualities desired have all changed but the tradition still remains that apprentice course ought to be four years in length or of some other considerable period. The time required to make practically all the products of industry has been reduced to a fraction of the time formerly employed. The time required in school has increased materially. If our schools were adapted to the needs of the majority, the time required after leaving school to learn a trade or the demands of a job ought to be reduced. If an apprentice course is two years, three years, or four years in length it deters many from entering that field and drives them by economic choice or necessity to selecting a white-collar type of job where the worker gains a greater degree of independence in a shorter period of time, although the limiting wage of the latter job may be lower. We cannot expect the youth to make long-time investments when immediate or at least visible returns are what he wants.

There is no doubt but that the considerable length of apprentice courses deters college graduates from entering certain fields for which they are equipped and where those who have entered have succeeded. A noticeable trend away from such long courses has been observed recently. Is it necessary that apprentice courses should be two to four years in length or are some of them so as a matter of tradition? This needs to be given careful study in order to decrease the time of so-called "improductivity" to its lowest reasonable terms.

There is another unattractive feature. The pay of the apprentice is low. It seems logical that it should be. It has always been and he was "improductive" for a part at least of the time that he was "articled."

In those days it was not supposed that the apprentice would remain with his master when he had learned the trade. He usually set up in business for himself. Now the situation is radically different. Few apprentices and practically none in some fields can become independent or semi-independent factors in production. That is well known to the employer and even to the learner. To what extent should the employer capitalize the fact—after the probation period—that he is building up a more skilful and more efficient employee? Records of apprentice courses show such a

considerable percentage of apprentices as remaining for long periods—if given work—as to justify the question.

Occasionally it occurs that a college graduate has entered an apprentice course only to find that if he had taken a job instead he might have been earning considerably more income with the same firm.

With all the facts before us of lack of experience, present ignorance of the job, and immaturity, can we make apprentice courses attractive if a job as a semi-skilled workman brings more pay than the apprentice receives? This is not always true, but have the industries and the railroads appraised the potential value of apprentices so as to attract the most desirable material?

It seems desirable for our larger cities to adopt the day and night trade school of Great Britain or the junior technical high school in order to better equip a part of our youth for industry. We already have shorthand and bookkeeping.

But the schools can never prepare boys for all the various trades and parts of trades. The industries should utilize school methods so far as practicable, supplement them, and then utilize the idea or organized instruction.

The length of apprentice courses should be carefully studied with a view of reducing them when feasible. This problem is difficult but not unsolvable.

It seems desirable that the industries consider the potential value to them of a better-trained man and the pay which they can afford to give during the training period. Necessity has led to marked improvement in pay with many firms, but certain groups have not realized the value of selection, training, and pay on their labor turnover. This is often looked upon as a social rather than an industrial problem. At present it is an industrial problem.

Labor as Means of Social Salvation

By IRA N. HOLLIS, WORCESTER, MASS.

THE two most important activities of the United States, or in fact of any country, are labor, in connection with the industries of all kinds, and agriculture, in connection with the products of the forests and farms. We are reminded every day that the second is what we live by, but it is equally true that the second is supported by the first, inasmuch as the implements and the machinery necessary to work the land for an enormous population are precedent to the raising of food supplies. We shall have to reckon with both of these interests. One of them is very evident in Congress through the farm block, and the other we have had for the past fifty years through the labor union.

A great change has taken place in this country since the establishment of its government more than a hundred years ago. Then ninety per cent of the population was engaged in farming or agriculture in some form, while today fifty-five per cent of the population is crowded into the cities for manufacturing of some kind. Neither one of these two has had the attention through education and training that they both deserve. The labor unions have done something toward training their men, especially in localities, but they have not yet fully attempted the task of making their men more valuable and worth more pay by reason of better training. Too much of the other thing has taken place, namely, limiting the work of every individual to that of the least skilled and least intelligent.

Outside of the labor unions we know that many schools have grown up in the corporations, in states, cities, and by private endowment, for the education and training of men to enter the industries. Every member of our Society is familiar with the engineering colleges which prepare for a profession with its literature and technique, but few of them really know the school which we sometimes describe as "below college grade." Such schools have had a more or less fluctuating existence in the industries themselves, and we have not yet even begun to standardize them in such a way as to have a well-recognized routine for preparing young men to become intelligent mechanics, even in the small industries. For this reason, our Committee on Education and Training may be of great service to the members of the A.S.M.E. and to the public by gathering together a sufficient report on the methods in the present schools and, to some extent, on their locations. We know perfectly well that the future of America is going to depend upon a better morale, and that morale will grow in proportion to an intelligent understanding of what the country needs in its workshops.

A report such as would be sufficient requires money, and it is possible that the A.S.M.E. may not find itself in a position to finance such an undertaking, but nothing could be better for the country than money spent in that way. We know perfectly well that the attitude of mind of the average workman, and even of the farmer, toward work is quite different from that of even fifty years ago. Then a mechanic took pride in his skill and in the work of his hands, which had in some way a moral influence. The establishment of great industries with their thousands of employees has so divided labor that the individual can no longer feel the pride in the completed machine that the mechanics of our boyhood felt. How can a change be effected? We do not know, largely because we do not know the methods now that are commonly followed for apprenticeship and training. We know something about it, but nothing very definite. It may be that an undertaking such as this Committee might contemplate, namely, a full report on schools of the United States and their methods of training for mechanical industries, is beyond us, but certainly we can do something toward at least disseminating information among our own members. This Committee has been in existence some years, and it has been feeling its way through synopses of the task to be undertaken and of the possibilities for the future. Up to this time, however, we have not had the money to make even an impression upon the entire problem. This meeting in Cleveland is encouraging because it does show that the interest is being kept alive. Believing that there is nothing more important to our country than a better solution of the whole labor question, and than a cultivated pride in the work of every man, I think the Committee should go on, and that every interest should assist it. It ought to be coöperative in every way, so that we can work with every association in the United States and with the Government, in order that our efforts may not be wasted through duplication. I say these few words only by way of encouragement, believing that we have made progress and that the Committee, as at present constituted with Mr. Faig as chairman and Mr. Edmands as secretary, is amply capable of pushing the work ahead, at least little by little, until we come to something.

Engineering Foundation

THE Report of the Engineering Foundation for the year ending February 14, 1924, records the continued coöperation of the Foundation with the National Research Council and indicates substantial progress in the investigations in which the Engineering Foundation is participating.

The financial report showed an expenditure during the calendar year 1923 of $20,416.68 and an income of $28,062.64, the balance carried into 1924 being $34,668.23. Of the expenditures, $8,583.15 was devoted to research projects, $7,895.80 to the promotion of research, and $3,937.73 for administration.

The Report also includes the third report on the Fatigue of Metals, the research in which is being carried out at the University of Illinois Experiment Station by H. F. Moore and T. M. Jasper. This report is reviewed on page 487 of this issue.

Riveted Joints

THOUGH riveted joints have been employed for many years, there are still a number of important questions as to their design and construction that have not been settled. The Special Research Committee on Riveted Joints of the A.S.M.E. has these questions under consideration, and Dr. A. H. Stang, of the Bureau of Standards, has prepared a remarkably complete bibliography on the subject which has been published by the Society through the coöperation of the Bureau of Standards.

This bibliography contains a list of articles, papers, etc., giving the results of tests on riveted joints, a list of articles dealing with methods of testing and chapters of textbooks which treat of riveted-joint design. It should be of great assistance to those who are grappling with problems of joint design.

This publication, is on sale by the A.S.M.E. at seventy-five cents per copy to members and eighty-five cents to non-members.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Research on Steam Nozzles

Third Report of the Steam Nozzles Research Committee of the Institution of Mechanical Engineers

THE Second Report of the Committee, published in the Proceedings of the Institution of Mechanical Engineers for March, 1923, was abstracted in its main features in MECHANICAL ENGINEERING for March, 1924, p. 148. Curves in this report showed the relation between the velocity coefficient ϕ and the theoretical steam speed c for: (*a*) 1-in. standard Parsons 480 B nozzles with 20-deg. nominal angle; and (*b*) convergent impulse nozzles with 20-deg. nominal angle and thin partition plates.

It was shown in the Second Report that at very low steam velocities (300–450 ft. per sec.) the mean curve through a series of test points may be taken as accurate to ± 1.0 per cent. As the steam speed increases this degree of accuracy becomes ± 0.5 per cent at medium velocities (1000–1200 ft. per sec.) and ± 0.4 per cent at the highest velocities reached in these tests (2000–2300 ft. per sec.). The range of steam speed (300 to 2300 ft. per sec.) covered by these curves is considerably greater than has previously been obtained in one apparatus and all five curves have one marked characteristic, namely, an upward sweep toward the lowest velocities of the tests.

In the present Report will be found all the tests on the convergent impulse nozzles, 20-deg. nominal angle, with thick partition plates. These tests were carried out on the nozzle box made at that time. The nozzle box is shown as Fig. 1. In addition a series of tests was devised to determine the effect of chamfer on the exit edges of comparatively thick plates and the above nozzle box was used for this purpose.

This Report also includes the work on $^3/_8$-in. Parsons standard 430 B blades, which emphasizes the effect of entry on nozzle efficiency; and the first test results of a set of straight elementary nozzles which were designed by Prof. A. L. Mellanby.

TEST RESULTS

Impulse Nozzles, 20-deg. Nominal Angle, Thick Partition Plates. It will be noted from Fig. 1 that the ratio of parallel portion to throat opening is $^3/_4$ in. to 1 in., or three to one. It was found expedient to block up the opening of the nozzle furthest away from the plate in the tester, and to carry out the tests with three nozzles functioning. To obtain the highest velocities two nozzles only were used but in every set of tests yet made the "overlap" between two and three nozzles falls within the accuracy of the curve. The results of some 36 tests on these nozzles with three openings are shown plotted in curve 7, Fig. 2. The points marked "2" represent two nozzles functioning and the points marked "C" are check points taken on different days.

Further tests have shown that no effect could be detected of an intermediate throat length between 1 to 1, and no parallel portion at all. Curve 10, Fig. 2, gives the results of tests of this nozzle with no parallel portion in the throat. The curve follows in general the same shape as the other three curves, but the same degree of accuracy could not be obtained as is shown by a wider divergence of test points at similar velocities. Too much stress should, possibly, not be laid on this point except that it tends to confirm the experience of the similar nozzle with thin partition plates, namely, that an impulse nozzle with no parallel tail portion is not quite so stable as one in which a certain amount of guidance is provided.

On Curve 8 are also shown the results of two tests at about 470 ft. per sec. which are lower than the two tests at 650 ft. per sec. To a certain extent this peculiarity, which is new, repeats itself on the 0/1 throat of Curve 10, and it is perhaps unfortunate that Curve 9 was not completed in order to supply further evidence on this point. It is hardly possible to do more at present than to note that after all due precautions had been taken and after the test results had been subjected to very careful scrutiny these points emerged as having been obtained. One result of the curves shown in Fig. 2 is to demonstrate that in a 20-deg. nozzle with thick partition plates and with considerable other disturbing influences at work the effect of length of throat is negligible between ratios of 3 to 1 and 0 to 1.

Impulse Nozzles. 20-deg. Nominal Angle. Thick Partition Plates with Chamfered Exit. A series of tests were carried out on the same nozzle box with the aim of detecting the effect, if any, of chamfering the exit edge of the forward plate of each nozzle with the view to diminishing the "flapping" effect of the flat surface which, in the case of $^3/_{16}$-in. plates with a nominal angle of 20 deg., amounted to about $^9/_{16}$ in. between each nozzle.

The comparison of mean average curves shows clearly the detrimental effect of flat surfaces in the exit plane of nozzles and the improvements which may be anticipated by suitable chamfering.

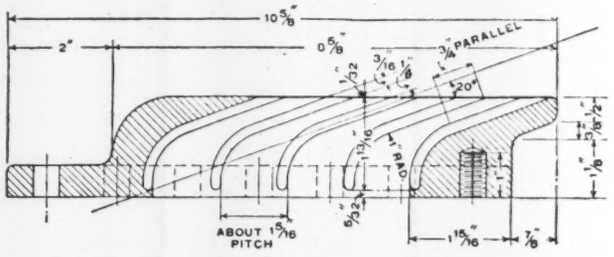

FIG. 1 IMPULSE NOZZLE BOX, NOZZLE 2 IN. HIGH
(Angle 20 deg.; plates $^3/_{16}$ in. thick.)

The Efflux Angles of the Steam. The efflux angle tests of the First and Second Reports were taken by a laborious and slow photographic method. The tests for this Report were obtained by an optical method described in the Report which is much more rapid and sufficiently precise. From this Report it would appear that there are, in reality, two angles to be considered in the case of an impulse nozzle which consists of cast-in parallel plates of appreciable thickness as shown in the original article. There is first the angle θ made between the parallel plates and the plane of the diaphragm. There is secondly an angle δ made between the chamfered plates and the plane of the diaphragm. The first angle, θ, is the geometrical angle of the nozzle and $\sin \theta = o/q$. The second angle, δ, may be termed the "reference angle" of the nozzle, and $\sin \delta = o/p$.

A table in the Report shows that the angle of exit of the steam is very nearly the reference angle δ, and not the geometrical angle θ, as is often assumed in design. This has an important bearing on the velocity diagram and on the ratio of nozzle height to blade height. If a similar analysis is applied to Parsons normal blading it will be seen that such blading approximates to an impulse nozzle with thick plates chamfered off, but with a geometrical angle θ of about 37 deg. The usual angle measured in Parsons nozzles, however, is not θ but δ. The deductions from this work appear to be: (1) That the angle of setting in the tester of 14 deg. for the 20-deg. nominal thick-plate nozzles was satisfactory. (2) That the angle of efflux of thick-plate impulse nozzles whether chamfered or not is approximately the "reference" angle whose sine is o/p and not the geometrical angle whose sine is o/q. (3) The length of throat (with thin plates) has little, if any, effect on the mean angle of efflux.

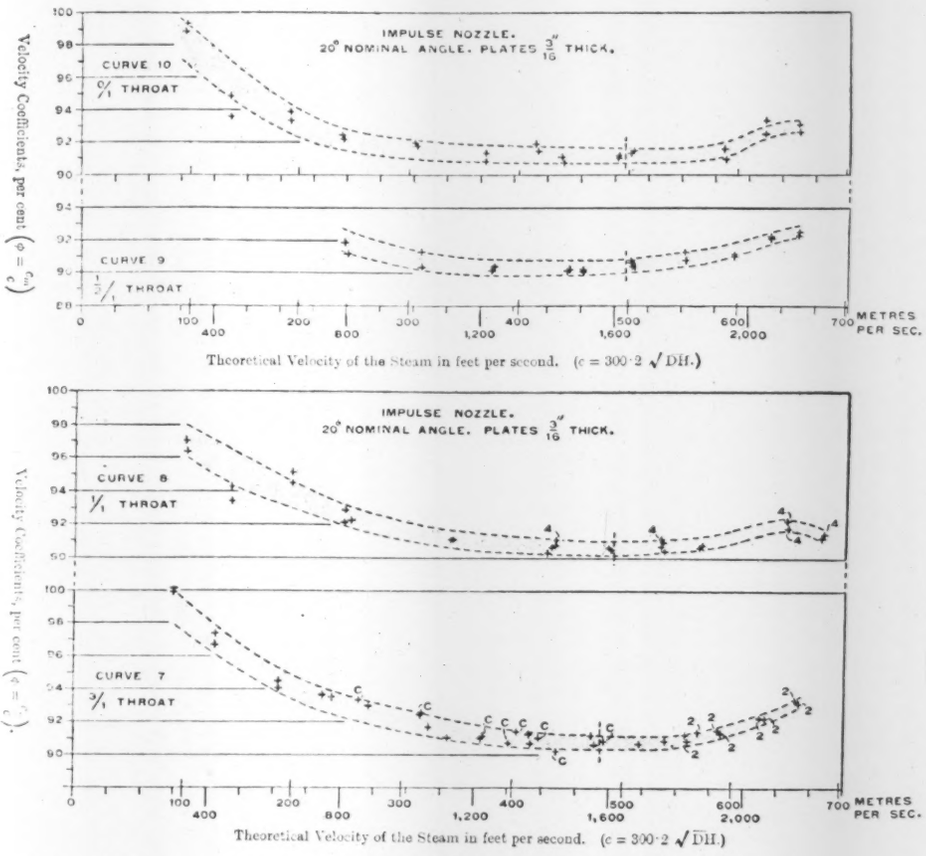

FIG. 2 PERFORMANCE CURVES, IMPULSE NOZZLE, 20 DEG. NOMINAL ANGLE, PLATES 3/16 IN. THICK

Reaction Nozzles. Tests were also made with a nozzle box holding ten 3/8-in. 430 B Parsons blading (shown in the original Report). From the results of 38 tests taken with this arrangement it was found that considerable instability is present, particularly at lower velocities, and that the curve in general is very low in efficiency and different in shape from any previously obtained. From these tests and tests with the reconstructed nozzle it was found, however, that the true 3/8-in. nozzles curve is a replica of the 1-in. curve, though with a lower efficiency and that greater stability can be obtained.

Elementary Straight Nozzles. A start has also been made on the investigation of simple nozzles. The elementary straight nozzles selected for the first series of tests were designed by Professor Mellanby to give approximately the same hydraulic mean depth and the same total discharge area as the curved nozzles which had already been studied. This nozzle with its new pipe is shown in Fig. 3. It consists of seven circular, machine-finished holes, 1/2 in. in diameter by 1 3/4 in. long, with well-rounded entry, arranged symmetrically around the central axis of the tester. This gives a cross-sectional area of 1.37 sq. in. as compared with the average of 1.5 sq. in. of the curved forms of nozzles. For a slit with opening o the hydraulic mean depth is $o/2$, and for a pipe with diameter d, the hydraulic mean depth is $d/4$, hence a slit of 1/4 in. opening is equivalent to a pipe 1/2 in. in diameter. The exit face of this nozzle is set at the standard distance of 2 1/2 in. from the top mesh of the cage plate, but arrangements have been made for altering this distance from 6 1/2 in. to 1/2 in. The nozzle pipe itself could not be made perfectly cylindrical, but had to be slightly convergent to enable the whole to be lowered easily inside the cage of the tester. The internal diameter of this pipe just before the nozzles is constant over some length and is 5 9/16 in. The bottom inside corner is given a radius of 1/2 in. to avoid eddies in the steam. The point of the nozzle itself is cut away at an angle of 45 deg. to prevent, as far as possible, interference with the escape of the steam into the exhaust chamber after striking the plate.

The results of some 36 tests with this nozzle are given in the original in the form of a table and curves. It was found that beyond 800 ft. per sec. this nozzle is at least 5 per cent more efficient than any of the other nozzles and that the general shape of the curve, while differing from the majority of the other nozzles, does bear a resemblance to the 3/8-in. Parsons nozzle with bad entry. In both these cases there is a distinct rise in efficiency between about 600 ft. per sec. and the critical velocity of about 1600 ft. per sec., which is more pronounced than in most of the other nozzles tested up to the present. There is also an indication of the "turning over" of the curves at very low velocities, which was predicted by Mr. H. M. Martin in the discussion on the Second Report.

CONCLUSIONS

Among the conclusions arrived at, attention may be called to the following.

1 The general shape of the curves obtained for the velocity coefficients of steam nozzles is corroborated and in one or two cases the curve has been carried sufficiently far into the low velocity region to indicate that it "turns over," as predicted by Mr. Martin.

2 The effect of chamfering thick plates of convergent impulse nozzles is clearly shown by the work in this Report. It would appear that a thick-plate nozzle with a chamfered exit can be made as efficient, over a considerable working range, as a nozzle with very thin plates.

3 A straight elementary nozzle is in general 5 per cent more efficient than the practical types of nozzles which have been tested. The general shape of the curve, however, is very similar. A review of both Second and Third Reports goes to show that the condition of entry or of exit is important. The steam should approach the nozzle as smoothly and as slowly as possible and no flat surfaces should be left on the exit side of any nozzle.

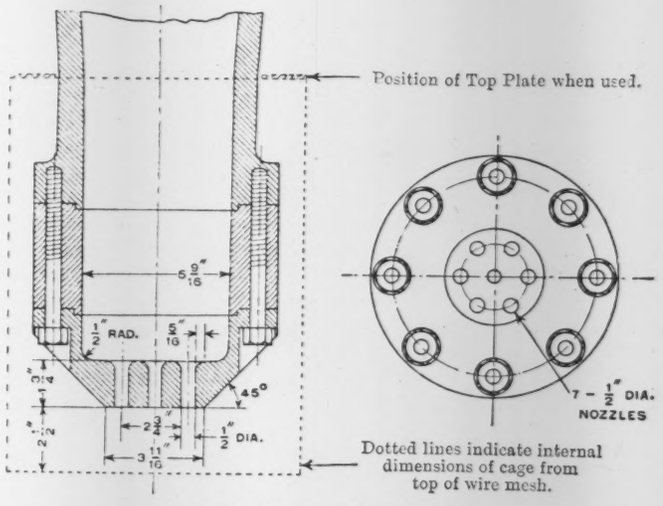

FIG. 3 ELEMENTARY NOZZLES

4 The effect of superheat, as shown in the case of the straight elementary nozzles with their higher efficiency, appears to lower the absolute efficiency of the nozzle and at the same time to move the curve bodily to the left. In this connection it should be noted that:

(*a*) A single set of nozzles only is being tested here and not a series of stages

(*b*) The comparison is between one degree of superheat and another, that is to say the steam is completely superheated from entry to exit conditions but in one case the average temperature is some 40 deg. cent. higher.

In view of the effect of superheat the original report gives information as to the character of the steam with which the curves have been obtained, which has not always been stated previously.

The work of the Committee is proceeding without interruption. The conclusions reached so far may be taken to apply to the particular nozzles already tested. These are in brief (*a*) Parsons standard 1-in. and $^3/_8$-in. nozzles; (*b*) impulse convergent 20-deg. nozzles with very thin partition plates (0.04 in.); (*c*) impulse convergent nozzles with very thick partition plate ($^3/_{16}$ in.), with and without chamfer at the exit edge; (*d*) straight elementary nozzles $^1/_2$-in. in diameter. In all tests the distance between the exit face of the nozzle and the top mesh of the cage plate was $2^1/_2$ in. (*Institution of Mechanical Engineers*, Preliminary Publication, read May 16, 1924, subject to revision, 47 pp., 14 figs., *eA*)

Short Abstracts of the Month

CORROSION

Symposium on Corrosion-Resistant Materials, American Society for Testing Materials

This symposium was presented at the annual meeting of the society held in Atlantic City, N. J., June 24 to 27. Among other things the Committee prepared a chart showing in tabular form the properties of the various alloys produced in this country, based on data obtained from the manufacturers of metals however, and not from independent tests. Following are abstracts of preprints of certain of the papers presented.

Characteristics of Material for Valves Operating at High Temperatures. This paper describes the results of laboratory tests and single- and multiple-cylinder engine tests of steel proposed for valve use, particularly with the view to service in valves of aircraft engines.

The operating temperature of the exhaust valve depends largely upon cylinder and valve design. If the valves are running black no trouble is experienced, but if a temperature of 1500 deg. fahr. is approached, the limitations of the various materials must be considered.

The quaternary alloys of iron, chromium nickel, and silicon, in which the range of chromium is from 6 to 15 per cent and the nickel 20 to 25 per cent, cannot be used in aircraft-engine valves, since they cannot be hardened sufficiently to prevent excessive galling of the stems and wear on the tips. The ternary alloys of iron, chromium, and tungsten are not satisfactory on account of heavy scaling. Chromium steel is not satisfactory, as it loses its hardness at high temperatures, which causes a galling of that portion of the valve stems subjected to the action of the exhaust flame. Cobalt-chromium steel gives the best stem conditions, but has a tendency to scale and burn in the head, although not to the same degree as tungsten steels. It is satisfactory except under unusual operating conditions. The ternary alloys of iron, silicon, and chromium satisfy the requirements of a valve steel in so far as the head and seat conditions are concerned, but they have the same drawback as the chromium steel in regard to softening of the stem in the section which is exposed to the action of the flame when the valve is open, but to a less degree. (J. B. Johnson, Chief, Material Section, Engineering Div., Air Service, McCook Field, Dayton, Ohio, and S. A. Christiansen, Power Plant Section, Engineering Div., Air Service, McCook Field, Dayton, Ohio, 19 pp., 12 figs., *e*)

Some Engineering Applications of High-Chromium-Iron Alloys. The author discusses in particular the use and limitations of an alloy with about 25 to 30 per cent of chromium and fractions of 1 per cent of silicon and manganese, the remainder largely iron. The carbon varies from about 0.1 to 3 per cent, depending on the properties desired.

The casting qualities are good and excellent castings are readily made throughout the range of carbon contents, which latter have an important effect on casting quality. As the metal runs from the spout it has a tendency to show a somewhat "creamy" appearance and sometimes forms a greenish leatherlike oxide, especially when the metal has been poured somewhat cold. The machinability and hardness of high-chromium alloys depends chiefly upon their carbon contents. Castings made in sand as a rule are easily machinable up to 1.5 per cent carbon and may be made machinable by suitable heat treatment with as high as 3 per cent carbon.

The oxidation resistance apparently depends chiefly upon the chromium content. Below about 20 per cent, while the alloys are very much more resistant to oxidation than ordinary steels, they are noticeably inferior in oxidation resistance to alloys above 20 per cent. Alloys with around 26 to 28 per cent chromium, when exposed to oxidizing atmospheres up to 1150 deg. cent. (2100 deg. fahr.) or higher, remain good indefinitely. They accumulate a very thin, tough, adherent scale of oxide which is more like an enamel than a scale, and this appears to act as a protective coating against further surface deterioration; it also resists flaking off, even when subjected to extreme changes of temperature. Carbon monoxide and other reducing fumes and gases are without effect until very high temperatures are reached; however, above 1150 or 1200 deg. cent. (2100 or 2200 deg. fahr.) such reducing atmospheres have a deteriorating effect on the alloys. At these temperatures, in the presence of carbon monoxide, actual oxidation takes place rather rapidly, and this has been explained by Charpy as being due to the action of the CO on the chromium, forming Cr_2O_3 and C, some of the latter combining with the iron. So long as the atmosphere is oxidizing, the alloys seem to be safe nearly up to their melting points. These melting points are determined chiefly by the carbon content, varying from 1150 deg. cent. (2100 deg. fahr.) for the very high-carbon combinations to 1430 deg. cent. (2600 deg. fahr.) for the low-carbon alloys.

The carbon content does not materially affect the oxidation resistance. In other words, the presence of chromium not only increases the resistance of the solid solution to attack by the hot oxygen, but it also apparently makes the double carbides more resistant. With the very high-chromium alloys there is enough chromium to alter the chemical nature of the solid solution and of the carbide as well, rendering both more inert. It is an interesting speculation here as to whether the essential nature of wet corrosion and of dry oxidation is not the same. It seems that this may well be the case; that is, the surface of the metal at high temperatures is ionized so that the chemical nature of the oxidation is analogous to that which takes place by acid attack in solution at room temperature.

Sulphur and sulphur gases are without action up to 1000 deg. cent. on the high-chromium alloys substantially free from other metals, at least so far as laboratory tests can demonstrate. Tests have been made in moist mixtures of sulphur dioxide and oxygen for several hours at 1000 deg. cent. (1832 deg. fahr.), and after this treatment only light tarnishes appear on bright metal specimens. Sulphur vapor is apparently without action up to at least 1000 deg. cent. (1832 deg. fahr.). At 1100 deg. cent. (2012 deg. fahr.) pure sulphur causes slow deterioration by attacking the grain boundaries. The latter test, however, was made with a sulphur ore in which the attack on the metal was highly complicated by the presence of a chemically active slag. Laboratory results indicate that up to 1000 deg. cent. (1832 deg. fahr.), stills for sulphur or sulphur gases could probably be safely used. The action of sulphur compounds in crude oil is believed by many to be the cause of the failure of steel stills in the oil-cracking industry. Tests that have been under way for some time are expected to demonstrate the usefulness of the alloy for this application. (C. E. MacQuigg, Union Carbide and Carbon Research Laboratories, Long Island City, N. Y., 10 pp., 6 figs., *e*)

The Carrying Capacity of Ball Bearings Made of Stainless Steel. Data of a series of tests conducted during the past six years in the Gothenburg Laboratory of the Swedish Ball Bearing Company. It would appear as regards carrying capacity that such ball bearings are very much inferior to ball bearings made of ordinary material and only slightly superior to such bearings made of bronze. The author points out that perhaps properly designed roller bearings of stainless steel may have sufficient carrying capacity to justify their use in cases where non-rusting material is necessary and the load is not too heavy. (Axel Hultgren, Chief Metallurgist, Aktiebolaget Svenska Kullagerfabriken (SKF), Gothenburg, Sweden, 7 pp., *e*)

Non-Rusting Chromium-Nickel Steels. Data of tests and in-

formation upon possible applications of two chrome-nickel steels from the tests at the Physical Research Laboratory of the Krupp Company, Germany. The first of these alloys, designated "VM" in the paper, is of martensitic structure and includes those steels containing from 10 to 16 per cent of chromium, 0.5 to 4 per cent of nickel and 0.1 to 0.6 per cent of carbon. The second, designated "VA" in the paper, is of austenitic structure and includes those steels containing from 20 to 25 per cent of chromium, 4 to 20 per cent of nickel, and 0.1 to 0.5 per cent of carbon.

The "VM" steel is applicable where great mechanical strength in conjunction with resistance to corrosion is required. The "VA" steels have by far the wider range of application. This material offers high resistance to mechanical wear, its perfectly non-magnetic, and can be made into thin sheets and wire. It is well adapted for a variety of uses in the chemical industries and may be considered as absolutely rustproof in damp air.

Corrosion tests were made on corrosion in air, in sea water and in cold and boiling nitric acid solutions, the two special steels being tested in comparison with steels of 9 and 25 per cent nickel content and ingot iron. The special steels proved to be superior to the three materials above referred to. (B. Strauss, Fried. Krupp, A. G., Essen, Germany, 10 pp., 5 figs., *e*)

Corrosion-Resisting Alloys for Use in Acid Mine Water. The main part of the information contained in this paper was previously published elsewhere as indicated in the bibliography appended to the original paper.

This paper points out the importance of the corrosion problem to the coal-mining industry. The nature of acid mine water from coal mines is discussed briefly, it being pointed out that such water causes corrosion largely by reason of its content of free sulphuric acid. Typical analyses of acid mine waters from bituminous coal mines are given. The impracticability of attempting to neutralize acid waters under ground is discussed.

The nature of the corrosion process in acid mine water is taken up, and the effects of the chemical composition of alloy materials and of the formation of coatings on corrosion rates have been emphasized. A résumé is given of the results of tests carried out by the U. S. Bureau of Mines during the past several years on the corrosion of ferrous and non-ferrous materials in acid mine waters from coal mines. It is shown that all ordinary commercial grades of iron and steels are corroded rapidly by such waters. The results of simple immersion tests on 45 metals and alloys in waters from three mines are summarized, it being found that of all the materials used, some five, namely, a high-chromium steel, two chromium-nickel-silicon steels, a high-silicon cast iron, and a nickel-chromium-alloy, were quite resistant. The microstructural aspects of these various materials after corrosion have been studied, and their principal features are discussed. The results of accelerated electrolytic corrosion tests on the above materials are summarized, it being found that the order of losses of the materials is roughly the same in both long-time immersion and accelerated tests.

On the basis of the various tests made, a list of materials which are resistant to acid mine waters has been drawn up, and the applicability of these materials to the construction of mining equipment is indicated. (Robt. J. Anderson, Metallurgist, U. S. Bureau of Mines, Experiment Station, Pittsburgh, Pa., and George M. Enos, Instructor in Metallurgy, University of Cincinnati, Cincinnati, Ohio, 14 pp., *eC*)

ENGINEERING MATERIALS (See also Corrosion)

Investigation of the Fatigue of Metals

REPORT of the work in progress during 1923 in connection with an investigation of the fatigue of metals which was organized in 1919 and carried on at the University of Illinois in co-operation with the National Research Council, the Engineering Foundation, and several manufacturing firms. Bulletin No. 124 of the Engineering Experiment Station of the University of Illinois contains the first report of the investigation and Bulletin No. 136 the second.

In the present report, which is the third, the various theories of the fatigue of metals are presented, the bulletin leaning apparently toward the slip-point theory, which is a modification of the progressive-failure theory.

As regards the endurance limit, it is stated that it has been discussed as if it were a sharply defined limit. It seems probable, however, that for any metal the endurance limit would not be sharply defined but would lie within a range of values. The possibility should be recognized that for stresses below the endurance limit (as determined in the laboratory) the spread of fractures may not be entirely prevented but only delayed, so that final fractures of the metal may occur after billions of repetitions of stress. On this point it is obvious that experimental data will be very difficult to get.

In the opinion of the authors the theory of the progressive fracture of materials under repeated stress explains, at least in a qualitative way, the observed relation between endurance limit and ultimate tensile strength in wrought ferrous metals. Fatigue failure of metal should be regarded as an actual tearing apart, and while the mechanism of failure differs in many details from that of failure in tension-test specimens, nevertheless the common feature of forcible separation of atoms or particles occurs in both cases, and it is this forcible tearing apart which constitutes fracture.

The endurance limits for wrought ferrous metals obtained in tests under reversed axial stress (tension and compression) are lower than those obtained under reversed-bending tests. This would seem reasonable in view of the greater opportunity for the development of cracks in a specimen uniformly stressed over its entire cross-section as compared with one having maximum stress only at the surfaces.

Among the conclusions arrived at the following may be reported here:

Additional evidence of the existence of an endurance limit for wrought ferrous metals is furnished by the results of retests of specimens which have withstood millions of cycles of stress without failure.

Repeated stress at or below the original endurance limit of a wrought ferrous metal raises the endurance limit for that metal. A wrought ferrous metal injured by such overstress may have its strength partly, but rarely wholly, restored by polishing its surface or by repeated stress below the endurance limit. The static strength of a wrought ferrous metal is increased in the same general way as is the endurance limit, by repeated stress below the endurance limit.

Under cycles of alternate axial tension and axial compression (completely reversed axial stress) specimens of wrought ferrous metals gave endurance limits averaging 64 per cent of the endurance limits for the same metals under cycles of reversed flexural stress. It is tentatively recommended that the endurance limit of wrought ferrous metals under reversed axial stress be considered as 60 per cent of the endurance limit under reversed flexural stress.

The static tensile strength and the endurance limit of wrought ferrous metals were found to be lower for specimens tested across the direction of rolling than for specimens tested along the direction of rolling. Test results for a number of specimens of wrought iron and of 0.37 per cent carbon steel indicate that the effect of the direction of rolling on the endurance limit is fully as great as the effect on the static ultimate tensile strength.

Test results of 48 specimens of 0.37 per cent carbon steel cut from a 4-in. billet and subsequently heat treated indicated some relative improvement of the strength of specimens tested across the direction of rolling as compared with specimens tested along the direction of rolling. The use of heat treating to improve the strength of steel across the direction of rolling is a problem worthy of further study.

For wrought ferrous metals the endurance limit for cycles of reversed shearing stress is about 53 per cent of that for cycles of reversed flexure. The endurance limits for reversed shearing stress were determined by tests of specimens under cycles of reversed torsion.

Preliminary tests of specimens of annealed copper, annealed brass, annealed bronze, and hot-rolled monel metal have not yet determined that these metals have an endurance limit. If such a limit exists it may be necessary to carry fatigue tests to hundreds of millions of cycles of stress to determine it.

For flexural stress or for axial tensile stress either one of the following equations gives safe values of endurance limit for wrought

ferrous metals under cycles of partially reversed stress or of stress varying from zero to a maximum:

$$S_r = S_{-1}\frac{r+3}{2} \text{ or } S_r = S_{-1}\sqrt{\frac{2}{1+r^2}}$$

in which S_r is the tensile unit stress at the endurance limit for the range of stress represented by r; S_{-1} is the tensile unit stress at the endurance limit for completely reversed stress; and r is the ratio of minimum stress to maximum stress for a cycle of stress. Data are lacking for determining the endurance limit for cases in which r is positive.

For shearing stress the test data available indicate that for the wrought ferrous metals tested the endurance limit for cycles of stress varying from zero to a maximum is nearly twice the endurance limit for cycles of completely reversed stress. In the absence of more complete data it may be noted that equations corresponding to those given in the preceding paragraph give results which are on the safe side for repeated shearing stress. (H. F. Moore, Mem. A.S.M.E., and T. M. Jasper, in *University of Illinois Engineering Experiment Station Bulletin*, vol. 21, no. 39, May 26, 1923 (Bulletin No. 142), 86 pp., 22 figs., *teA*)

FORGINGS (See Testing and Measurements)

FOUNDRY

New Process of Centrifugally Casting Cast-Iron Pipe

A STATEMENT dealing with a process developed jointly by a group of cast-iron-pipe manufacturers, of whom The American Cast Iron Pipe Co. of Birmingham, Ala., is known to be one.

While no complete details of the process have been published, it would appear that it employs a metal mold filled with sand, with or without a binder. In fact, as the statement is made that the sand in the flask is held in place by centrifugal action, it would appear that no binder is used in the main part of the mold. Pipe may be cast of any thickness, heavy or light. Not only the bell but the spigot or bead end can be formed by this new method, probably by the use of small cores at the end.

The refractory material which has been applied to the sand mold is of such a character that during the casting operation it becomes incorporated by a fusing action with the outer shell of the casting, thus forming a coating which prevents the formation of rust or corrosion and acts as a protection to the pipe.

Cast-iron pipe made by this process has been tested in hydraulic presses, individual pipe being tested to 2400 lb. per sq. in. without showing defects.

Bars made from the actual casting have shown over 30,000 lb. per sq. in. in tensile stress and proportionate results in transverse and breaking tests.

This new sand-spun pipe is now being regularly made and marketed. Enlarged and up-to-date foundries are being built and all plants are being reconstructed for the installation of the new method, which will supersede the methods now employed.

As this pipe is cast in a sand-lined mold, it would appear that the conditions of cooling are such as to produce a fairly soft iron, thus making subsequent annealing superfluous. (*The Iron Age*, vol. 113, no. 23, June 5, 1924, p. 1660, *d*)

FUELS AND FIRING

Internal Heating in Low-Temperature Carbonization

DESCRIPTION of several British and Continental processes in which internal heating is used, namely, those of Everard Davies, Illingworth, Koppers, and Plauson.

The general principle of the Everard Davies process may be stated essentially as carbonization, with or without accompanying gasification by steaming, of such fuels as bituminous coals, brown coals, and lignites. The retort is a continuous vertical type heated externally on one side but heated internally by a small portion of the heating gases passing through the descending charge in a direction transverse to the charge length, i.e., through the charge thickness. External and internal heating are therefore combined, and up to about 25 per cent of the heating flue gases after being spent by external heating are passed through a descending charge in the retort. Data as to the production and cost of operation are given in the original article. A plant to carbonize 200 tons per day will cost about £80,000 to install in England.

The Illingworth process has for its object the conversion of coals that swell excessively into coals from which a dense smokeless fuel is evolved. Illingworth preheats coal to a temperature not above 500 deg. cent. (932 deg. fahr.) out of contact with air so as to destroy as far as possible the β cellulosic and resinic substances. The process is conducted at a temperature below that at which the coal forms a coherent mass, usually below 400 deg. cent., so that a non-coherent product is obtained which can be charged directly into the retort for distillation at 900 to 1000 deg. cent. (1652 to 1832 deg. fahr.).

As an example, a coal forming a hard coke and giving 30 per cent volatiles at 900 deg. cent. (1652 deg. fahr.) was found to form coke structure at 360 to 380 deg. cent. (680 to 716 deg. fahr.). This coal was heated to 300 deg. cent. (572 deg. fahr.) for $2^1/_2$ hr. out of contact with air, and on the ash-free dry basis lost 2.5 per cent of weight, and no coke or sintered product was formed. The temperature was raised to 400 deg. cent. (752 deg. fahr.) and after a further 2 hr. heating the additional loss was 2 per cent, with no formation of coke or sinter. This product had no coking properties above 400 deg. cent. (752 deg. fahr.), and not even when heated suddenly to 900 deg. cent. (1652 deg. fahr.), though it retained the same appearance as the original coal. Thus it is possible fully to carbonize a coking coal by means of successive stages of heating—that is to say, all the volatile matter can be expelled, but no coke will be formed in the process.

In the Koppers process coal is carbonized by passing through its mass a number of preheated steel balls. These balls are preheated in an adjacent heating chamber, are fed into the worm with the charge, and are present in sufficient number to assure carbonization.

It is claimed that the steel balls prevent caking of the charge during the period of plasticity. The balls are 100 mm. (3.93 in.) in diameter and are heated to about 800 deg. cent. (1472 deg. fahr.).

The Plauson process is based not on distillation but on mechanical driving off of oils and other products with a high boiling point by passing through the fuel superheated steam or an inert gas at the rate of 300 to 600 meters (984 to 1968 ft.) per sec.

The fuel is broken into 3-in. cubes and charged into a vertical cylinder which has at 3 ft. from its lower end an annular ring carrying a number of nozzles similar to those used in steam turbines. The fuel is in a layer about 3 ft. thick, the steam being forced through under pressure and taken off at the top of the retort, where it passed into condensers. The steam is generated at 15 atmos. pressure, and the lower end of the retort is water jacketed to cool the coke, which is drawn off by a worm, and also to supply the boiler with preheated water.

The process is applicable both to bituminous coal and oil shale, and some data are given in regard to typical yields from this process. (C. H. S. Tupholme, London, England, in *Chemical and Metallurgical Engineering*, vol. 30, no. 22, June 2, 1924, pp. 861–863, *d*)

HYDRAULIC MACHINERY (See Railroad Engineering)

INTERNAL-COMBUSTION ENGINEERING

The Screening of Magnetos

AT THE last Epsom Races in England the Technical Section of the Scotland Yard in conjunction with the Marconi Company developed a method of regulating the traffic over a wide area round the course by means of three motor tenders equipped with wireless as well as a kite balloon similarly equipped.

One of the problems that arose involved the screening the magnetos of the trucks so that the electrical disturbances created by them would not interfere with the reception of messages inside the vans. This problem is of interest, because of the various statements to the effect that motor cars and aircraft could be put out of business by high-frequency waves which would short-circuit the

magnetos. It is obvious, of course, that if the electrical disturbances created by the magnetos can be screened from affecting outside apparatus, so can the magnetos be protected from interference from external sources.

In this instance the screening is effected by the use of specially constructed spark plugs which are provided with outside threads to receive metallic cones covering the terminals. Further screening is secured by covering the magneto leads with woven-wire sheathing, grounded to the frame, while the whole magneto is covered with copper gauze so arranged as to collect any discharge from the distributor or contact breaker and carry it to the ground, so as to prevent radiation. (Traffic Control at the Derby, in *The Times Trade and Engineering Supplement*, vol. 14, no. 309, June 7, 1924, p. 306, *d*)

INTERNAL-COMBUSTION ENGINEERING

The Engine of the Godet-Varielle Diminutive "Six"

DESCRIPTION of the Godet-Vareille six-cylinder automobile, a rather unusual type. It has an engine 49.7 mm. by 64 mm. (1.95 in. by 2.51 in.), giving a piston displacement of 745 cc. The cylinders are cast separately and mounted on the upper half of an aluminum base chamber. The water space around the cylinders is very liberal. The construction is such that uniform thickness of cylinder walls is obtained, and there is much more space between pairs of cylinders than is possible with the usual method of producing cylinders and jacket in one casting. As the studs and holding-down nuts are always in water, they are given a preliminary anti-rust treatment.

The vertical valves are positively operated in a manner which not only assures perfect seating at extremely high speeds (speeds as high as 6000 r.p.m. have been employed in bench tests and the normal output of 35 b.hp. is obtained at 4000 r.p.m.) but provides for elongation of the valve stem and is claimed to be perfectly silent in operation. There are two camshafts in the same vertical plane, the lower one opening and the upper one closing the valves by means of rocker arms, the outer end of each rocker being received between the two pairs of cams, and the opposite end having a link connection to the valve stem. In this way the rocker exerts alternately a push and a pull action on the valve stem.

If this device were used with an ordinary type of rocker arm having a fixed fulcrum point the construction would have to be extremely accurate to assure gastightness, and any elongation of the valve stem or even a particle of foreign matter finding its way between the valve face and its seat would inevitably cause a breakage and possibly wreck the engine.

This difficulty is overcome in the Godet-Vareille engine by an elastic mounting of the fulcrum point, which assures the final seating of the valve and provides for elongation of the metals. The rocker is mounted in a vertical stud screwed in the cylinder head and having two slots at right angles to one another; the rocker passes through one of these slots and the rocker shaft through the other.

A sliding fit on the stud is a ring, described by the inventor as a cradle piece, in which the rocker shaft is mounted and having its under face in contact with a light coil spring. A collar is slipped over the stud and screwed down to the cradle by means of a nut and lock nut. This gives a rocker with one end between the two cams, the opposite end linked to the extremity of the valve stem, and its shaft capable of moving vertically, to a limited degree, in the slot provided in the stud. Under the action of the spring the rocker is pushed upward, tending to keep the valve closed, and the extremity of the rocker is always maintained in contact with the upper or closing cam, any play which may exist being between the dead face of the lower, or opening, cam and the rocker.

The vertical movement of the rocker, under the influence of the spring, is slight, being no more than 2 or 3 mm. (0.078 or 0.118 in.); this is sufficient, however, to provide for all elongation that may take place, and the light spring assures the final seating of the valve without any danger of rupture.

The engine is equipped with a supercharger, for which purpose is used a rotary blower driven from the same shaft which operates the high-tension distributer for battery ignition. (*The Autocar*, vol. 52, no. 1492, May 23, 1924, pp. 935–936, 6 figs., *d*)

MACHINE DESIGN

Stress Distribution in Crankshafts and Its Relation to Crankshaft Failures

DATA and conclusions from investigations of failed crankshafts examined at the Naval Engineering Experiment Station, including a large number of airplane crankshafts.

Because of lack of space only the main conclusions of this interesting article can be presented here. Examination of these failed crankshafts has shown in only a few cases is the material defective or inferior to the specified quality. In the great majority of such shafts the cause of failure must be assigned to some deficiency in design. Such deficiency in turn can usually be traced to lack of data in regard to the amount and distribution of the stresses in rapidly rotating objects of such complicated form. In crankshafts under service conditions there is no doubt that frequently the moment of torque and consequently the stress greatly exceed any value obtained by the usual methods of calculation. The distribution of stress in a crankshaft, moreover, is evidently very different from the usual assumptions of the designing engineer.

In a crankshaft with unrestrained journals under uniform journal torque, the stresses in the journals and pins are purely torsional and those in the webs are purely transverse bending.

In a crankshaft with restrained journals under uniform journal torque, restraint of lateral movement of journals may or may not cause torsional stress in the webs. Whether such stress is produced depends on the type of shaft. In a four-throw, three-bearing shaft, web torque is not thus produced. In a four-throw, five-bearing shaft or in a six-throw, seven-bearing shaft, web torque is thus produced.

In a shaft of a type subject to web torque an approximate estimate of web torque may be made by multiplying the value for journal torque by $l/2R$, in which l represents the distance between the axes of the two pins adjacent to a web and R the distance between axes of pin and journal.

Study of typical airplane-crankshaft failures shows that when the calculated transverse web bending stress is less than the calculated resultant stress in the web due chiefly to torque, fracture starts at a reëntrant angle between a web and either a pin or a journal. Such fractures are not due to transverse bending stresses.

In a few crankshafts of old design the calculated transverse bending stress in the web is greater than the calculated resultant shear stress. Such shafts may fail by transverse bending fracture of a web.

In marine and submarine crankshafts with few exceptions the nominal stress distribution is much more uniform than in airplane shafts. Such shafts, if they contain radial oil holes, usually fail in a journal, the crack starting in an oil hole. If oil holes are absent they may fail in a web.

In radial oil holes in shafts the stress concentration varies somewhat with the class of steel used. In the class of steel used in airplane crankshafts the stress concentration is about two to one.

It is desirable that crankshafts be so designed that, with web torque calculated as described above, the stress distribution will be as uniform as possible. (D. J. McAdam, Jr., and G. F. Wohlgemuth, metallurgist, and associate metallurgist, respectively, at the Naval Engineering Experiment Station, Annapolis, Md., in *Journal of the American Society of Naval Engineers*, vol. 36, no. 2, May, 1924, pp. 244–281, 29 figs., *etA*)

MACHINE PARTS (See Corrosion, Ball Bearings)

MACHINE SHOP

An Improved Method of Locomotive Erection by the Use of Erecting Forms

THE enormous growth in the size of modern locomotives as compared with what they were only a few years ago has reached the point where the boiler plate is $1^1/_2$ in. thick and the main frames are made of a section 9 in. wide weighing 40,000 lb. and held together by cross-ties and foot plates that weigh as much as an entire locomotive weighed a few years ago.

This led to an intensive effort to secure the highest possible accuracy in the production of locomotive parts, but when it came

to erecting the locomotive a good deal was left to the care and skill of the individual mechanic, a method which at best was not sufficiently reliable and uniform in results. It was to eliminate as much as possible the individual factor that John P. Sykes, senior vice-president of the Baldwin Locomotive Company, brought forward the idea of a mechanical erector, called in the shop vernacular "erecting form," a device for the absolute control of the work of erecting a locomotive that eliminates all possibility of errors in alignment, inequalities of measurement, and all the variances formerly existent in locomotives incidental to the exercise of personal judgment or skill on the part of the workman.

The first essential of the erecting forms was absolute rigidity in the matter of foundations, and to obtain this twelve heavy concrete piles were driven down to solid rock foundation. On this piling a heavy reinforced-concrete mat was poured.

The bedplate, which is an important feature of this device, is an iron casting 24 ft. long, 80 in. wide, and 8 in. thick. It is carefully

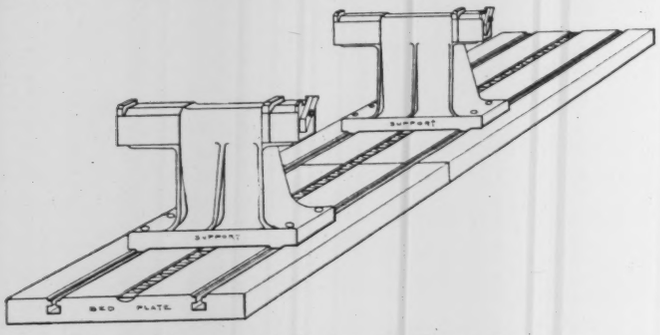

FIG. 1 DIAGRAM OF FORMS AND THEIR BEDPLATE

machined over its entire six surfaces and has two V-shaped grooves planed out the entire length of the plate. It is accurately leveled, resting on a series of cast-iron beams imbedded in the concrete mat mentioned. On these bedplates two cast-iron supports identical in all dimensions are carried. These supports are designed to carry the weight of the heaviest locomotives.

The bases of these supports are formed to engage the slides in the bedplates through the agency of two shears, which are machined with micrometric precision and which enable the supports to be moved to any longitudinal location on the bedplate, maintaining the same accuracy of alignment that occurs in the moving of a lathe carriage along the lathe bed.

The plane occupied by the machined top surfaces is absolutely parallel with the machined surface of the bedplate so that the top surfaces of the supports are always level and in line with each other, irrespective of their distance apart.

The vertical faces of these supports are at right angles to their top surfaces; they are also perpendicular to the face of the bedplate and parallel to each other. Also these faces are transversely at right angles to the longitudinal center of the bedplate. A transverse perpendicular ledge or projection extends above the machined top surface for a distance of 1 in.; there is also a similar 1-in. projection extending at right angles to the vertical face.

It can be easily understood that a machined rectangular bar laid across the top faces of the supports and against the projections will automatically assume a level position both longitudinally and transversely, and will be parallel to the longitudinal axis of the bedplate. (Fig. 1.)

The front end of the erecting form is that end toward which the projection from the vertical faces extends. The front support is bolted immovably to the bedplate and one locomotive frame is lifted and placed so that the bottom surface of the frame rests on the top faces of the two supports, the ends of these supports extending through the pedestal openings of the frame.

On each support a clamp is fastened against the outside surface of the frame at the four projections described. At the same time a small screw operated by a short hand lever forces the frame back until the front pedestal faces are tight against the machined vertical surfaces of the supports.

The location now assumed by the engine frame being square, level, and plumb, the opposite frame is then lifted into place and the same procedure followed.

The two frames are then in the proper relative location toward each other, their pedestal faces are all in the same vertical plane, the gage between frames is correct and each frame is level along its longitudinal top surface.

The top surface of each frame is in the same horizontal plane and the frames are absolutely parallel.

The cylinders, cross-ties, foot plates, motion bearers, etc., have been machined to gage, but unless this machining has been accurate these parts cannot be put in place as there can be no compromise on dimensions and the rejected parts either must be corrected or replaced. (*Baldwin Locomotives*, vol. 3, no. 1, July, 1924, pp. 28–32, 8 figs., *dA*)

MEASURING APPARATUS

The Moullin Torsion Meter

THE measurement of the brake horsepower transmitted through shafting while in regular work is often required for many purposes, of which one of the more important is connected with the power delivered to the propeller of a ship. The space in a ship's tunnel is not large, and the apparatus used should therefore be kept within the diameter of the couplings; the length of the selected portion of shaft is also limited to the clear distance between coupling and plummer block; it is also desirable that the indicator should be in the engine room, where it is most needed, and that the gear should be of such simple character that it will function without attention. These features have been kept in view in the design of the Moullin torsion meter now being made by the Cambridge Instrument Company, Limited, who have constructed apparatus for measuring the torque in shafts up to 10 in. in diameter and transmitting 1500 hp.

The instrument consists essentially of an air-gap choker, one half carried by a ring fixed to one point on the shaft and the other half carried adjacent to the first but attached to a sleeve fixed to the shaft about four feet away. The accompanying diagrams (Fig. 2), show the arrangement of the halves of the choker, of which one, *a*,

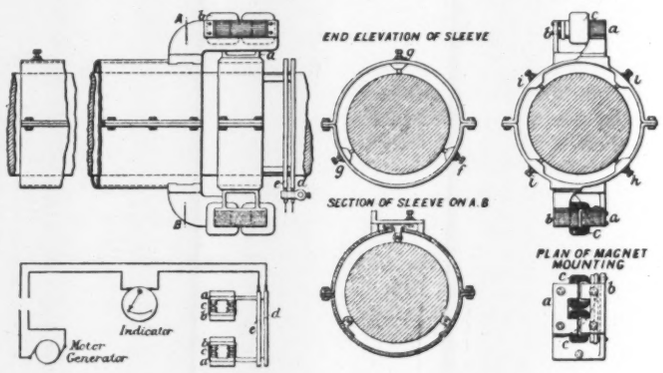

FIG. 2 THE MOULLIN TORSION METER

is fixed to the ring and the other, *b*, attached to the sleeve, the effective length over which the measurements are made being that between the normal planes of the two attachments. A small alternating-current generator supplies current to the windings *c* at 60 periods and about 100 volts. As the shaft twists the gap opens for forward running (and closes in running astern) and the current increases in direct proportion to the gap, thus giving a scale in linear proportion so that the measurements on a record vary directly with the torque.

The indicator is made in two forms, a visual pattern for commercial work consisting of a simple ammeter (see bottom of Fig. 2 at the left) controlled by the gear and scaled to read the mean integrated torque direct. The indicator may be placed at any distance from the shaft and may be in multiple to give readings in various parts of the ship. For a permanent record the ammeter is replaced by a standard Duddell oscillograph; by this means a continuous record is obtained of the instantaneous values in place of the mean reading given by the ammeter. The time scale that may conveniently be adopted is about 15 cm. per second, and the frequency, of course, is governed by the alternations at 60 per second. The vertical scale for the torque can be arranged to any convenient

height, and gives positive and negative readings for ahead and astern, respectively, during maneuvers. (*Engineering*, vol. 117, no. 3050, June 13, 1924, pp. 764–765, *d*)

Apparatus for Measuring Humidity

A DESCRIPTION of various types of hygrometers and of methods used in their calibration.

Probably one of the earliest devices for measuring humidity is one consisting primarily of a woman's hair, which changes its length with humidity. Other measurements of humidity were based on the ability of certain materials to change their color with the change in the dryness of the air. Such apparatus could be calibrated, of course, only empirically and were lacking in precision.

The article describes a number of such apparatus, many of which have only a historical interest, while others, such as one based on the difference in reading of a dry-bulb and a wet-bulb thermometer, are well known.

Somewhat more interesting are the following apparatus for humidity measurements of the air which are readable at a distance and also provide for direct reading of the psychometric difference.

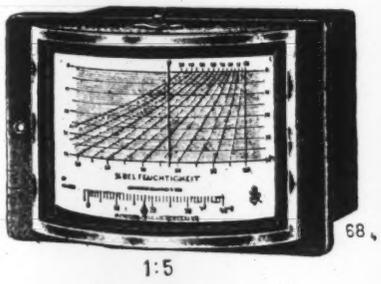

FIG. 3 HARTMANN & BRAUN DISTANT-READING HYGROMETER

In the Konstanz Schmitz meter built by the Siemens & Halske Company an electrically driven fan forces air past a dry and wet resistance thermometer. An electrically controlled scale is provided with push-button-operated means for cutting in the fan and reading the dry and wet thermometers.

Hartmann and Braun built a thermoelectric distance-reading hygrometer. The employment of the thermo elements in a compensating winding permits direct reading of the relative humidity content in percentages. The pointer of an indicating galvanometer moves over a Jelinek psychometer chart on which, provided the absolute room temperature is known, the moisture content of the air may be read directly in percentages. There is no artificial supply of air flow over the thermo elements. Fig. 3 shows the reading scale with the pointer and another figure in the original article shows the electrical connections.

There are also a number of apparatus for single determinations of humidity in gases. The hygrometers described above can be used exclusively for the determination of water vapor in air provided the air is at fairly low temperatures. For measurement of humidity in gases possessing a high sensible heat and in cases where they are contaminated by the presence of tar, soot, or dust, the apparatus described above is not suitable and special apparatus has to be used.

Of these special apparatus some are used for individual determinations of water-vapor content in gas, such determinations taking from 10 to 30 min. to make, and other apparatus is such as to permit instantaneous reading of the moisture content. The simplest in principle is that of Mueller, of Essen, in which the entire hot-gas mixture is cooled to a temperature below the dewpoint. The water of condensation is then weighed and the gas measured by a gas meter.

In the Naegel apparatus the measurement of humidity is based on the measurement of the variation of pressure occurring in a given closed volume of gas as a result of its cooling below the dewpoint temperature of the vapor that may be present in the gas. The humidity content may then be determined either graphically or by computation.

The standard instrument of the Düsseldorf Heat Bureau of the Association of German Steel Plants has two thermometers contained in a glass vessel having double walls the space between which has been exhausted to a vacuum. The vessel containing the thermometers also contains two tubes by means of which gas may be supplied to the vessel or removed therefrom. The calculation of the humidity is carried on either in accordance with the method of psychometric differences or by direct reading of the dewpoint temperature, the velocity of flow of gas in the vessel being so regulated that both thermometers read the same. (Apparently it is the space between the two walls and not the vessel itself that is exhausted.)

The original article describes also an apparatus for the continuous determination of the humidity content of gases. (*Feuerungstechnik*, vol. 12, no. 17, June 1, 1924, pp. 141–144, 10 figs., *d*)

METALLURGY

The Hornsey Process for the Solid Reduction of Iron Ore

THIS process involves a series of kilns in the experimental plant, each about 5 ft. in diameter and 30 ft. in length. The material is preheated in the first kiln, reduced in the second, and cooled in the third, pulverized coal being used and the operating temperature being not above 1050 deg. cent. (1922 deg. fahr.).

The product differs physically from that of the blast furnace in that it is in a granular form instead of being in the shape of pigs. It also differs chemically in that the iron reclaimed is essentially pure, resembling wrought iron, and is mixed mechanically with varying percentages of the other ingredients of the ore instead of being chemically combined with it. The carbon content, generally speaking, is lower than that of pig iron but can be controlled at will within reasonable limits.

The Hornsey furnace produces a steel intermediate which may be used to make refined steel or wrought iron. This intermediate product can be handled in the open hearth, preferably starting with a small bath of molten pig iron.

The solid-reduction metal was converted into wrought iron, crucible steel, and plain carbon steel, and the original article gives data on the physical properties of axle temper steel made from Hornsey material as compared with two standard, plain-carbon steels of the same character. (*Iron Trade Review*, vol. 74, no. 25, June 19, 1924, pp. 1635–1636, 1 fig., 1 table, *d*)

PIPE (See Foundry; Welding)

POWER GENERATION

Water Power in the Pulp and Paper Industry in Canada

STATISTICAL data as to the use of water power in the pulp and paper industry in Canada. Among other things, it would appear that low-cost power is essential to the industry as it takes practically 100 hp. on an average to make one ton of paper per day. Ninety per cent of the motive power in this industry is derived from abundant and advantageously located water falls.

While stating the average consumption of power for the conversion of pulp wood into paper as 100 hp. per ton per day, some average figures based on general conditions in the trade might be quoted to show how this large amount of power is used. One large and representative Canadian mill uses on the average 73 hp. for each ton of mechanical pulp produced, 67 hp. of which is for the actual grinding alone. The production of sulphite pulp for mixing with the groundwood pulp required 8.7 hp. per ton of daily output (in other large mills as high as 30 hp. was used per ton of sulphite pulp produced), while the conversion of the pulp to newsprint required 12 hp. for the same unit of output.

The continuous operation of mills in this industry, usually 24 hr. per day, lends itself to the securing of a very low cost per unit of power used where the power is derived from water, as the main item in this cost is the interest on the capital expended in the hydraulic development and this remains constant whether the plant operates ten hours a day or twenty-four. The development of the electric steam generator has also become an added factor in reducing this unit cost, in that any surplus or off-peak power which may be available can be utilized for producing steam for pulp cooking, drying, heating, and similar uses.

At the present time the hydraulic power utilized in the pulp and paper industry totals to 726,375 hp., and the rapidly growing change to the elastic electric drive is shown by the fact that 438,708 hp., or over 60 per cent of this total, is converted into electricity before use. Of this latter total, 210,053 hp. is connected to generators installed in the mills and power stations belonging to the operating companies, while 228,755 hp. is purchased from central

electric stations. The advantages of this conversion to electricity appear both in the quality of the product, which is improved by the uniform speed obtained, and in the fact that under modern methods of transmission it is possible to develop power at one or more sites more or less remote from centers of labor and transportation and to transmit it to points where these commodities are available for mill operation and for providing supplies of raw materials and conveying the finished products to the markets. The best modern practice in pulp-mill construction provides for the development of the mill and power sites as separate projects, i.e., the site of the mill is selected from the point of view of operation and transportation, while the power station or stations may, if efficiency of development and generation demand it, be placed in positions unfavorable to mill construction. The use of steam as a source of power for this industry is very limited and is in many cases prompted by special conditions such as operation in close connection with the manufacture of lumber when refuse from the latter can be used as fuel under the boilers.

The last completed census conducted by the Dominion Bureau of Statistics, that for the year 1922, shows a steam-power installation in pulp and paper mills of only 60,764 hp., or less than 10 per cent of the total installation. (*Department of the Interior, Canada Dominion Water Power Branch*, Bulletin No. 731, March 1, 1924, mimeographed, 6 pp. of text and numerous illustrations, *s*)

POWER-PLANT ENGINEERING

The North Lees Power Station

THIS station belonging to the North-Eastern Power Companies is considered to be the last word in power-plant design in England. The fact that a boiler pressure of 475 lb. per sq. in. and a steam temperature of 700 deg. fahr. were adopted as long ago as 1917 when the station was designed, indicated the boldness of design, while the reheating of the steam, the use of air preheaters instead of economizers, and the system of multi-stage feedwater heating are all features of the most advanced practice. The station was designed for an overall thermal efficiency of 21 per cent in routine operation, to attain which it would be necessary to produce a kilowatt-hour for 16,271 B.t.u. as average working practice. As a result of the depression of industry on the Northeast Coast the load conditions were such that this ideal has not yet been attained.

In view of the departures in design introduced into the new plant it was decided to build a complete self-contained two-unit station so arranged that it could eventually either be treated as an annex to a larger station operating under the same cycle conditions or if, as a result of the experience, modifications in the cycle conditions were found desirable it could be kept entirely separate from any extension plant.

The two most interesting features are the provisions made for the reheating of the steam and the preheating of the air. The reheating of steam between the high- and low-pressure cylinders is carried out by leading the steam to heaters forming an integral part of some of the boiler units. Partly because of this the boiler house is arranged parallel to the engine room, the turbo-alternator sets being arranged lengthwise in the engine room. Steps are taken to prevent the accumulation of steam in the reheater from causing the turbine to run away and trip out if the load suddenly falls to zero. This is provided for by a special relay which operates a valve by passing the steam from the reheaters direct to the condenser.

The general design of the boiler units is similar to that of the ordinary marine type of water-tube boiler, but the tubes are smaller and the drums are of less diameter and made of thicker plate. The only difficulties arising with the higher pressure have been the liability of the gage glasses to fracture and the cutting of the seats of the valves. These troubles are being gradually overcome. The air heaters are of the simple tubular type, with spiral retarders inside the tubes which not only assist the heat transfer but also enable any deposit of dust from the flue gases to be readily cleaned out.

It is stated, among other things, that such of the special features of the design of the plant as the very high steam pressure, the reheating of the steam, or the preheating of air to the furnaces have not led to any special troubles in practice. (*Engineering*, vol. 117, no. 3050, June 13, 1924, pp. 753–755, 4 figs., 4 pp. of plates, *dA*)

PUMPS (See also Hydraulic Engineering)

Experimental Investigation of the Flow of Water through Rotating Cellular Wheel

IN THE rotor of a centrifugal pump a considerably smaller amount of energy undergoes transformation than would be expected in accordance with the usual water-filament theory of flow. This theory makes the assumption that the liquid discharges with equal velocity around the entire periphery and relatively under the angle of the working edge of the vane. If there is no guide apparatus in front of the rotating wheel the absolute direction of the incoming liquid is meridional and the transformation of energy is computed under the above assumptions. It has been found that the actual amount of transformation of energy is smaller than that determined by a formula derived under the above assumptions, and in order to obtain formulas that would give the results compatible with actual practice, there has been introduced the conception of an "effective" radius of discharge that is smaller than the actual radius, and of "effective" area of discharge or velocity of discharge. There has not been a clear knowledge of the actual process of flow occurring in the rotor and hence of the precise cause of the reduction of transformation of energy as compared with what it should be in accordance with the theoretical formula. The present author, while in the Graduate School of the Swiss Federal Technical School, undertook as his thesis for the year 1922 an investigation of this problem by methods that would permit of a visual examination of the phenomena of flow in a rotating pump wheel. This was done by means of coloring the flowing liquid and by taking still and moving-picture photographs. Because of lack of space the experimental methods cannot be described here, and only some of the results obtained will be referred to.

FIG. 4 RELATIVE FLOW IN ROTORS OF CENTRIFUGAL PUMPS

Relative Flow. The speed in revolutions experimentally determined for the inlet of liquid without shock corresponds with the speed as computed on the basis of the streamline-flow theory. Even at normal speed, i.e., at shockless inlet, on the concave side of the vane some of the liquid breaks off, the result being that the relative direction of discharge taken with respect to the vane angle is flattened out (compare Figs. 4 and 5) and thereby the transformation of energy is decreased. The relative flow is not stationary (it would be stationary in the case of a frictionless flow), but the variations in the direction of flow do not show any clearly determinable frequency. They originate apparently primarily in the friction and its concomitant phenomena, such as turbulence. With smaller amounts of water the flow at the discharge is less quiet than with larger amounts, because at smaller velocities of flow greater turbulence becomes possible.

FIG. 5 HYDRAULIC RELATIVE FLOW IN ROTORS OF CENTRIFUGAL PUMPS

Comparison between Absolute Flows. The direction of the arriving current is radial and independent of the value of Q/n, where Q is the amount of liquid flowing per second, and n the r.p.m. of the wheel. The absolute angle of discharge increases with an increase of Q/n.

The transformation of energy may be computed from the absolute directions of flow as determined by measurements. In particular, when the arriving current is absolutely radial with

respect to the running wheel the following formula holds good:

$$L = \omega \frac{\gamma Q^2}{g \times 2\pi B} \cot \delta$$

where L is the output, γ the specific weight of the liquid, ω the peripheral velocity, Q the amount of liquid passing per second, B the width of the discharge side of the wheel, and δ the angle which the direction of flow (measured at the circle, the diameter of which is greater than $2r_2$ where the non-stationary influence of the wheel vanes is no more noticeable) makes with the peripheral direction. Two other formulas were derived from tests on nine centrifugal pumps. (Heinrich Ortlei, Doctor of Science, in a thesis abstracted and published in *Schweizerische Bauzeitung*, vol. 383, no. 20, May 17, 1924, pp. 231–234, 13 figs., *e*)

RAILROAD ENGINEERING (See also Machine Shop)

Gasoline Passenger Car with Hydraulic Drive

DESCRIPTION of a combination passenger and baggage unit used on the New York, New Haven, and Hartford Railroad. It is propelled by a 150-hp. Ricardo engine through a Waterbury oil transmission consisting of a variable-delivery pump supplying oil to two variable-speed hydraulic motors, one mounted on each truck frame.

With this variable-speed transmission all variations in the speed of the car as well as reversal of the direction of movement are effected in the hydraulic variable-delivery pump, the engine running all the time at constant speed and in one direction only. The control of the delivery pump is effected by means of a servomotor described in detail in the original article. (*Railway Age*, vol. 76, no. 31, June 14, 1924, pp. 1507–1509, illustrated, *d*)

The Three-Cylinder Locomotive

IN THE last 25 years there has been a steady growth in the size and power of locomotives. By the end of the World War axle loads reached a value as high as 70,000 lb., and loads of 65,000 lb. were quite common.

The development of the locomotive has finally reached the stage where its upper limit has been set by the stress characteristics of rails and ties. With the two-cylinder simple locomotives the reciprocating and rotating weights of parts came to be such that the hammer blow on the rail of that weight, added to the driving-wheel counterbalance, formed a serious problem. In part it was met by the hollow boring of certain details and use of special materials, but the problem which confronts the locomotive designer today is to increase the tractive power without materially increasing the weight on drivers, to increase the boiler efficiency, and to reduce the counterbalance for reciprocating parts.

One of the proposed solutions for this problem which seems to have met with signal success is the use of three-cylinder locomotives, of which two designed by the American Locomotive Company have been placed within the past two years in service by the New York Central and Lehigh Valley Railroads.

The three-cylinder locomotive as such is not new, one having been designed in England and put into service in 1882. At that date, however, the three-cylinder locomotive was ahead of its time and was eventually abandoned. It was revived, lately under the influence of conditions stated above, and several types have been placed in service abroad, for example, in England and Germany. (Compare MECHANICAL ENGINEERING, vol. 41, March, 1919, p. 285, and vol. 43, March, 1921, p. 189.)

The three-cylinder locomotive on the New York Central Railroad was rebuilt from a standard 4–8–2 type. As reconstructed the cylinders were made 25 in. by 28 in. with 69-in. driving wheels, and the steam pressure was increased to 200 lb., giving a tractive power of 64,700 lb., an increase of 26 per cent over the original. The standard type of booster used on the New York Central was applied to the trailing axle, and a feedwater heater and stoker were added to the equipment.

The design of parts of the driving machinery was, in general, standard. The outside piston valves are actuated by a Walschaerts gear and the inside valve by a modification of the Gresley valve gear. The motion to the inside valve is imparted by a combination of levers so arranged as to give the proper steam distribution.

In addition to this the American Locomotive Company built in 1922 for experimental purposes a three-cylinder simple locomotive of the 4–8–2 type which was placed in service on the Lehigh Valley Railroad. The engine and steam characteristics on this engine are essentially the same as on the New York Central locomotive, except for minor details. It is a significant fact that these locomotives give a factor of adhesion of only 3.81 as compared with 4.5 for a two-cylinder locomotive of the same general type.

The most interesting of the mechanical details is the method of driving the inside valve motion from the two sets of outside valve gear.

Extensive tests have been carried out with this locomotive and the locomotive on the New York Central, both for handling heavy trains on level and on grades and for handling fast freight such as milk trains, the performance of the three-cylinder locomotives being compared with those of Mikado-, Santa Fe-, and Pacific-type engines. From these tests it would appear that the three-cylinder locomotive is capable of giving a highly satisfactory performance. In the first place, it has shown its ability to start trains smoothly so that very rarely is there any damage done to the draft gears of the cars. The riding qualities of the locomotive are said to be remarkable for smoothness and freedom from lurching and vibration at high speeds.

The locomotive has furthermore shown the ability of the boiler to maintain average boiler pressure under all conditions of service. It has also shown a high rate of speed obtained with full-tonnage trains, indicating a tractive power at speeds considerably higher than a two-cylinder locomotive of the same tractive power. Although theoretically the average power calculated in the usual way may be exactly the same for both the two- and the three-cylinder locomotives, the latter will start a heavier train and develop higher speeds because of more uniform torque, and because the minimum or stalling point of the three-cylinder is but 8 per cent below the average while that of the two-cylinder is 22 per cent. Also in the three-cylinder a higher average crank effort can be developed without slipping the drivers.

An important characteristic of the three-cylinder locomotive is that with the smaller diameter of its individual cylinders for the same amount of power as developed by the two-cylinder locomotive, the weight of the rotating and reciprocating parts for each individual cylinder is reduced. On account of this and because of the fact that the cranks are set at an angle of 120 deg., the hammer blow on the rail is materially reduced. As pointed out above, it is this element of stress on the rails and ties that was becoming in many instances the limiting factor to the further increase in the power developed by the locomotive.

It would appear at first sight that with the use of three cylinders a larger boiler would be required, but it has been found that the three-cylinder locomotive is more economical in the use of both fuel and steam, and as a consequence the boiler requirements are not as great as would naturally be expected. This is also true because of the more even draft on the fire due to the three exhausts per revolution of the driving wheels, which, in turn, permits of a larger exhaust nozzle with less back pressure in the cylinders.

Against these advantages of the three-cylinder locomotive as compared with the two-cylinder there is the additional cost of maintenance of the three-cylinder with its connections and the crank axle. (Editorial based to a certain extent on a paper read by George C. Jones before the Western Railway Club and a record of tests compiled by W. I. Cantley, Mechanical Engineer, Lehigh Valley Railroad. *Railway Review*, vol. 74, no. 24, June 14, 1924, pp. 1079–1093, illustrated, *dA*)

SPECIAL PROCESSES (See Fuels and Firing)

TESTING AND MEASUREMENTS

Inspecting Large Forgings by the Borescope

THE article here abstracted contains a description of an instrument developed by Aldis Brothers, Sparkhill, Birmingham, England, for inspecting the internal surface of large forgings, such as turbine rotors. At present the practice in Great Britain is to bore a hole

through the center of important solid forgings and examine the structure of the steel thus revealed in the interior of the piece. To examine the structure after the bore has been drilled, use is made of the "borescope," which is really a periscope provided with a lens close to the point of examination.

The main features of the instrument are shown in an illustration in the original article. A small high-powered electric lamp is placed in the end of the instrument which is essentially a tube 1.48 in. in diameter by 13½ ft. in length. A reflecting mirror reflects the image of the steel on the side of the bore through a nearby lens, which, in turn, transmits it through various lenses to the focusing eyepiece, giving an enlarged view of the steel in the side of the bore. By rotating the instrument and moving it through the bore step by step, every part of the structure of the interior of the forging can be examined. An alternative form of the instrument permits the whole circumference of the bore to be examined at once, much as if one were looking down a tube with one eye, except that the structure is shown considerably magnified.

By means of these instruments every mark, scratch, discoloration, or stain can be seen. The result is the same as if the forging were split from end to end into two halves and examined through a reading glass. In other words, the instrument is intended to give the examiner the sense of having inspected the whole surface of the bore while illuminated, by a powerful magnifying glass. The degree of magnification is uniform. When anything of a suspicious character comes within the field of view it is comparatively easy to examine it in detail and to photograph it if desired. When examining forgings by means of an exterior telescope it has been found that turning marks have sometimes been mistaken for defects, while a bad join-up between borings from either end may also lead to a similar misunderstanding. Close examination of the detail of the interior of the bore avoids these difficulties.

British engineers are of the opinion that the slight weakening resulting from the boring of a small hole through the center of a large forging is more than counterbalanced by the certainty that the remaining metal is sound. (*Iron Trade Review*, vol. 74, no. 24, June 12, 1924, pp. 1557–1558, 4 figs., *d*)

VARIA

Mercury Poisoning

AS A RESULT of a study of the effect of small quantities of mercury vapor on workers in laboratories or industrial plants, Dr. J. A. Turner, of the U. S. Public Health Service, among others, has arrived at the following conclusions:

Daily exposure to an atmosphere containing as small a quantity as 0.02 mg. of mercury per cubic foot of air results in signs and symptoms of poisoning. The histories indicate that daily exposure must continue for two to three months, or more, before symptoms begin to appear.

It is estimated that in exposure to the above-mentioned quantity of mercury for three to five hours daily there is a total daily absorption of mercury ranging from 0.771 to 1.285 mg., according to the duration of exposure.

The symptoms of chronic mercury poisoning are stated in some detail. It would appear that the best method of solving the problem of prevention of mercurial poisoning is by making it impossible for the workmen to inhale the mercury fumes. (U. S. Public Health Service Report No. 903. Abstracted through *Chemical and Metallurgical Engineering*, vol. 30, no. 25, June 23, 1924, p. 980, *g*)

WELDING

Welding Iron Pipe with Tobin Bronze

DESCRIPTION of tests conducted at the plant of The American Cast Iron Pipe Co., Birmingham, Ala., on welding cast-iron pipe using Tobin bronze.

These tests showed the average strength of a well-made bronze welded joint on a 6-in. cast-iron pipe to be 68,333 lb. per sq. in. of bronze section. Tests of the cast-iron pipe showed it to have an average strength of 22,631 lb. per sq. in. or about a third that of the weld.

In view of these tests the writer formulates the rule of making bronze welds one-third as thick as the pipe and three times as wide as the pipe is thick.

In bronze welding a temperature ranging from 1450 to 1650 deg. fahr. is used. This is important as these low temperatures do not injuriously affect the structure of cast iron.

Standard Tobin bronze contains 60 per cent copper, 39.25 per cent zinc, and 0.75 per cent tin, and has a melting point of about 885 deg. cent. (1625 deg. fahr.). (H. Y. Carson, Research Engineer of The American Cast Iron Pipe Co., Birmingham, Ala., in a paper before the Cleveland Meeting of the Natural Gas Association of America; abstracted through *The Foundry*, vol. 52, no. 12, June 15, 1924, pp. 469–470, 2 figs., *d*)

Electric Welding of Monel Metal

MONEL metal must be deoxidized in producing arc welds. (In acetylene welding, however, special deoxidation is not necessary because a reducing flame is used.) The deoxidizers which are found to be superior for this purpose are magnesium, manganese, and silicon, in the order of their importance. These deoxidizers are best employed in the form of alloys, ground to from 50 to 100 mesh and applied to the welding rod of bare monel metal wire as a thin coating. A successful binder can be made of denatured alcohol containing 8 oz. of shellac to 1 gal. of alcohol. An excess of manganese is not harmful, but an excess of magnesium or silicon tends to produce dirty or brittle metal. The preparation and composition of deoxidizing powder and the sizes of welding rods are given in full in the original article.

In the actual operation of welding it is best to make the whole weld at one operation, and not to build up in successive layers, as the latter method will probably result in cracks and unsoundness. The weld should also be well built up above the surface, as there are almost invariably pinholes or cavities just below the surface of the weld.

An important variation from the usual practice in the arc welding of steel is that of making the welding rod positive instead of the work. When the latter is made positive the metal tends to drop from the electrode and does not flow freely and continuously.

In arc welding the best results are obtained when the metal surfaces to be joined are clean and free from scale or dirt. The work may be cleaned either by machining, grinding, filing, or sandblasting. After both edges of the weld are perfectly clean it is advisable to coat them with the same deoxidizer as is used on the welding rod.

Monel-metal arc welding differs from steel welding in that it is necessary to puddle the metal at the weld so that impurities may be brought to the top, and it is good practice for rods ½ in. in diameter and upward to put a small mold around the parts being welded, either of fireclay or carbon block, to prevent molten metal from flowing away. In double-vee welding the work should be heated to a cherry red before the second side is welded, so as to prevent any possible shrinkage cracking. By hammering the weld while hot, a metal with a much higher tensile strength is obtained.

Monel metal from 1/64 in. to ⅛ in. thick can be successfully spot welded, but the welding must be done very quickly. It requires about half the time and twice the current to spot weld monel metal that is required for steel of the same thickness. It is not advisable to attempt to arc weld metal under 1/16-in. in thickness. Beveling the edges is not necessary for metal 1/16 to ⅛ in. thick. When the metal is more than ⅛-in. in thickness, the entire thickness of each side should be beveled at an angle of about 45 deg.

Electric resistance butt-welding machines are entirely suitable for monel metal, but the conditions of welding are somewhat different. Seam welding may also be used. (A. E. in *Machinery* (Lond.), vol. 24, no. 607, May 15, 1924, pp. 203–204, *p*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

Preferred Numbers

TO THE EDITOR:

In the July issue of MECHANICAL ENGINEERING, page 429, Mr. C. C. Stutz, Secretary of the American Institute of Weights and Measures, discusses the subject of preferred numbers, refers to a paper by the present writers,[1] and asks certain direct questions.

First, what is a preferred-number series? This question Mr. Stutz answers for himself by stating that "a set of preferred numbers is any set of numbers forming a . . . . geometrical progression . . ." This idea is entirely erroneous, and we think it proper to set forth at some length what we believe to be the truth.

A preferred-number series is exactly what its name says it is, i.e., a series of numbers which are preferred over other numbers. Whether rationally or otherwise, we do actually prefer some numbers over others. The designer will establish a dimension at $^{3}/_{4}$ inch in preference to $^{47}/_{64}$ inch. In every line of work there are definitely established systems of preferred numbers, and present-day rational study of industrial and technical development leads naturally to the question, what is the best basis for any series of preferred numbers? In reply to this question it is rather generally conceded that a geometrical series is in many cases the most desirable, but the idea of preferred numbers does not necessarily entail the use of a geometrical progression.

If it is agreed that a geometrical series is to be used it is necessary to select a ratio, and in this there is much difference of opinion, as might be expected, since the selection is more or less arbitrary.

The desiderata which must be considered are:

a The series should be as simple as possible

b The series should be suitable for use in various arts and industries, the very same series of numbers being used to designate magnitude in feet, inches, pounds, ounces, tons, gallons, kilowatts, square feet, etc.

c The series should cover a very wide range of relative magnitude

d The series should be capable of easy reduction by the omission of intermediate terms, so that various numbers of steps can be secured within any desired range of magnitude. Such shorter series should conform to desiderata *a*, *b*, and *c* in the same manner as the complete series.

The first desideratum is met by a series which repeats itself in successive intervals. Since the series itself is a geometrical progression, the intervals through which it repeats must likewise be in geometrical progression. Shall these intervals lie between successive powers of 10, or of 12, or of some other number?

Since we have 12 inches per foot, this number seems altogether a good choice until we examine it more in detail. The basic series would comprise terms from 1 inch to 12 inches, each term being some number of inches plus some decimal fraction of an inch. The first repetition for large sizes would run from 1 foot to 12 feet, with decimal fractions of a *foot*. If the terms of this second series were expressed in inches, the numbers would not have the same sequence of figures as those between 1 and 12 inches, and the series would therefore not repeat itself. The next step will give us a series between 12 and 144 feet, and if the same series of numbers is to be repeated, this group must be based on a new unit of 12 feet, each term being expressed as some multiple of this unit, involving decimal fractions thereof.

Extending this 12-base series in the other direction introduces equally disturbing factors. The first group below 1 inch would range from $^{1}/_{12}$ inch to 1 inch, and the unit would be $^{1}/_{12}$ inch, each term being some multiple of this unit, with decimal fractions thereof.

The series based on roots of 2, given by Mr. Stutz in his Table 2, furnishes another illustration of the same difficulty. To cover any extended range it is necessary to refer to a full series; there is no repetition of any sequences of digits.

Perhaps these illustrations suffice to indicate the difficulty of fitting any system of preferred numbers into any given system of weights and measures. The difficulty is very fundamental, and is perhaps best set forth by observing again the name of the thing we are discussing—preferred *numbers*. We are not referring to preferred sizes or weights, but to numbers, and the series which we adopt must fit into our system of *numbers*. This basic concept cannot be too strongly emphasized. We are dealing with a series of numbers which has nothing whatever to do with the system of units employed for the magnitude under consideration. What we have here is a series of numbers, and, as such, they simply must fit into our system of counting. The method of expressing fractions of a unit has led some critics astray. In a formally stated preferred-number series, decimals are employed as a matter of course. These could indeed be reduced to the nearest sixty-fourth, but this would be a step away from current industrial practice, not toward it. Modern shop production methods are tending constantly and strongly toward the use of decimal fractions of small units: witness the increasing practice of dimensioning machine drawings in inches and thousandths, with decimal tolerances. This, however, is an irrelevant question; what we wish to stress here is that preferred numbers are abstract numbers pure and simple, fitting into our system of arithmetical notation and used to designate magnitudes in terms of whatever physical units we may choose.

If the series fails to fit into any given system of units, the fault lies not with the series, but with the system of notation which lies at the basis of our arithmetic. This we cannot hope to change, and even were such a change possible, should we change to the base 12 to suit our inch-foot system, or to 16 to suit our ounce-pound system, or to some other base?

To meet the second criterion, that the series chosen must be widely applicable, it is absolutely essential that it be chosen to fit into the only universal scheme we have, namely, our decimal system of numbers. Then the series will be usable in any art of industry, whatever the physical units employed.

Any system employing as ratio a root of 10 does fit into our number system perfectly, and may therefore be extended indefinitely toward either larger or smaller numbers without difficulty. The basic series, from 1 to 10, may be taken in terms of inches, feet, millimeters, pounds, tons, or gallons with equal facility, and in any of these terms the series for other ranges, e.g., from 0.001 to 0.01, or from 10,000 to 100,000, may be secured by simply shifting the decimal point.

Thus it seems to us that the 10-base series meets the first three desiderata listed above. The series is very simple, widely applicable, and, because it is very easily extended, it covers an infinite range of magnitudes.

The fourth desideratum requires that partial series may readily be taken from the complete series, and that each of these partial series shall itself meet the desiderata under discussion. That is, each partial series must be capable of extension to other ranges by simply shifting the decimal point. Now let us see what this means.

Suppose we adopt for our basic ratio the 17th root of 10. This will give us a series of 18 terms, of which the first is 1 and the eighteenth 10. This series is readily changed in range by shifting the decimal point. But suppose that we wish to select from this series a partial series with, let us say, half as many terms. To

[1] Size Standardization by Preferred Numbers. Presented at the A.S.M.E. Annual Meeting in 1922, and published in MECHANICAL ENGINEERING, December, 1922, p. 791.

this end, let us omit alternate terms from the series, giving us the series

$$1, 10^{2/17}, 10^{4/17}, \ldots 10^{4/17}, 10^{16/17}, 10^{18/17}, \ldots$$

It will be noted that this series has for its ratio the value $10^{2/17}$ and that it does not include the number 10. In other words, this series cannot be extended to cover the range from 10 to 100 by shifting the decimal point.

Similar difficulties will be encountered if it is desired to select shorter series by retaining every third, fourth, or fifth term of the series based on the 17th root of 10. The defect is evidently that 17 is a prime number.

In contrast, let us select a root of 10 whose index is not a prime number, e.g., 8. The 8th root of 10 series will be

$$1, 10^{1/8}, 10^{2/8}, \ldots 10^{7/8}, 10, \ldots$$

If we select alternate terms from this series, we obtain a new series,

$$1, 10^{2/8}, 10^{4/8}, 10^{6/8}, 10, \ldots$$

whose ratio is $10^{2/8} = 10^{1/4}$, and this is obviously a new series of exactly the same class as the original, that is, it includes the numbers 1 and 10, and is capable of indefinite extension by shifting the decimal point.

The choice of 80 as the index of the root of 10 which is the basic ratio was doubtless made because this index contains 2 as a factor four times. The choice of an index containing more factors might present some advantages, but there would be a very serious disadvantage in the fact that such an index must necessarily be large, increasing the number of terms in the series. For example, if we wish to retain 2 as a factor four times and desire to introduce 3 three times and 5 twice, we have for our index

$$2^4 \times 3^3 \times 5^2 = 10{,}800$$

The use of this index would obviously give a series with far too many terms for practical use.

The index 80 enables us to make up shorter series by taking alternate terms in four successive steps, giving ultimately a series whose ratio is the 5th root of 10, which therefore is basically a series of six terms, the first being 1 and the sixth 10. In cases in which fewer steps are desired, these steps are usually determined without reference to the nature of the series to which they conform.

If we are willing to reduce the number of successive divisions by two, it would appear that there is some advantage in using the 60th root of 10. Since $60 = 2 \times 2 \times 3 \times 5$, we may take alternate terms twice, or each third or fifth term. This series, which has been suggested, thus has something to recommend it, and should be given careful consideration.

We believe that we have covered Mr. Stutz's third question, concerning the outstanding characteristics of what he incorrectly calls the "German series." In his second question he asks whether the use of such a series is new, and this he answers in the negative, citing instances of the use of geometrical series (not based on any root of 10) as early as 1857. These facts we do not question. If, in our original paper, we gave the impression that the use of a geometrical series is an idea of recent origin, we certainly did not intend to do so, for the idea is far from new.

Neither is it a new idea to use a geometrical series whose ratio is a root of 10. Mr. Stutz implies that this scheme originated in Germany, but we believe that this was not the case. Records show that a series based on the 10th root of 10 was studied and applied by Colonel Charles Renard, a noted French engineer, in 1879, and in 1886 the practice was made public in "Instruction pratique sur les Aerostats Militaires," published by the French War Ministry. The French Commission Permanent de Standardisation accordingly proposed that this basic series be officially designated as the "Série de Renard," or, in English, the "Series of Renard." This might prove a graceful though slight memorial to a great and capable man, and at the same time a convenient name for a useful series.

In adjusting the series which they have recently adopted, European engineers have rounded off many of the numbers in a somewhat inconsistent manner, and Mr. Stutz objects that this vitiates the entire scheme. We are not prepared to defend the details of this rounding off; indeed, in our original paper we said: "The authors believe that it may be a mistake to round out the numbers in these tables. . . . the extent of rounding in some cases is so great as to entirely mask the original value . . . much can be said in favor of preserving the peculiar decimal fractions."

There seems to be some effort to entangle this question with that of the adoption of the metric system of weights and measures. We have already pointed out that the use of series based on roots of 10 has no relation to any system of weights and measures, but is recommended because it fits nicely into our system of numbers as a series of preferred *numbers*. If the series covers sizes of drills, for example, there is no reason why the final numbers should not be rounded out to 64ths of an inch, if for any reason that seemed the best practice.

Mr. Stutz objects that the use of the series based on the 80th root of 10 is altogether utopian, impractical, undesirable and impossible, that it would require years for its introduction and entail a cost of billions. These are powerful objections, but it seems to the authors that some of them, at least, are open to difference of opinion. That the scheme is utopian, to some extent, is admitted joyfully by all its friends. It does indeed present some phases of a distinct step toward a better order. The charge of impracticality must always be met by any new development which by its very newness departs from accepted details of current practice. That it is undesirable we do not admit. That it is impossible is absurd. It would indeed take time to introduce such a system, but the expense we doubt. The longer the time, the less the cost, it seems to us. Moreover, such a change need not be made over night. Changes come upon us unawares, and if we can but direct such changes toward a rational goal, we shall presently find ourselves living in a new order. If engineers generally will study the subject of rational standardization and lay out a sensible course, then manufacturers, when selecting new sizes for their product, can introduce here and there little excerpts from a unified system, and as older designs become obsolete we shall find our manufactured products increasingly taking on the characteristics of an ordered system. In fact, exactly this process is already taking place in a few cases, as has been brought out by the discussion presented with the original paper, as well as elsewhere. This makes it doubly important that we lose no time in studying the subject, so that a proper course may be mapped out to avoid whatever pitfalls it may be possible to foresee. Some definite action is needed, for if we are to advance effectively we must advance together along the lines of some commonly accepted plan.

Let us quote from the closing paragraph of our original paper: "The authors themselves hold no brief for preferred numbers, but they do believe that the idea indicates possibilities of simplification and elimination of waste of such magnitude that thorough investigation is justified." Our view is thus far unaltered. In this scheme we believe we see great possibilities for future benefits, at the expense, it is true, of some immediate sacrifices; and we still believe that thorough and intelligent study of the matter is imperative if we are to continue to advance.

It would be a splendid thing if more attention could be given to the matter by persons like Mr. Stutz and the authors, who have no direct connection with the production of dimensioned parts and who therefore may be assumed to be free from prejudice and unbound by tradition. It is through the prosecution of such intensive studies, for purely altruistic motives, that we, as individual engineers and citizens, and as a society devoted to the welfare of mankind, can serve our fellow-men by bringing to all of them through increased economy of production and more useful output per man-hour of labor, an era of greater comfort, peace, and security.

C. F. Hirshfeld
C. H. Berry.

Detroit, Mich.

To the Editor:

In the July, 1924, issue of Mechanical Engineering there appeared a communication from Mr. C. C. Stutz in which he set forth a series of numbers in geometrical progression possessing certain well-recognized advantages.

Starting his series with the very convenient numeral 100 he derives the following numbers 100, 200, 400, 800, 1600, and 3200—numbers which should appear, it seems to me, in all sets of "preferred numbers," not only because of their convenient 2-to-1 geometrical ratio but also by reason of their convenience in making calculations.

Between these numbers Mr. Stutz inserts certain intermediate values approximately (but not accurately) in geometrical progression, as in Group 1 below.

GROUP 1			GROUP 2		
100	400	1600	100	400	1600
126	504	2016	125	500	2000
159	635	2540	160	640	2500
200	800	3200	200	800	3200
252	1008		250	1000	
317	1270		320	1250	

His intermediate values could be made much more convenient for actual use without sacrificing accuracy to an unwarranted degree (maximum variation less than 2 per cent) by changing the intermediate values to read as in Group 2 above.

It will be noted that the modified series possesses the advantages of the 2-to-1 ratio which Mr. Stutz believes to be essential, together with the advantage of the 10-to-1 ratio which many people consider of much importance.

The modified series as here presented can be looked upon as having been developed directly from the "flexible, comprehensive, and familiar geometrical series upon which the English system of measures is based"—whatever that may mean. The only known objection to the series is that it is identical with the one used by the Germans (and many other Europeans) who use the metric system.

A. S. MCALLISTER.

Washington, D. C.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society, for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given interpretations of the Committee in Cases Nos. 441, and 443 to 445, inclusive, as formulated at the meeting of May 27, 1924, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 441

Inquiry: An interpretation is requested of the application of the rules of the A.S.M.E. Boiler Code to the computation of the strength of a flattened drum formed of two sections with riveted joints at their butting edges, one section comprising a semi-cylinder and the other a curved surface of long radius with flanged edges.

Reply: It is the opinion of the Committee that if the stress of the proposed drum is computed, neglecting the holding power of the tubes, it will be found to be extremely weak. The holding power of the tubes strengthens the drum, but there is no exact way of computing how much the tubes will assist in strengthening the drum. There are three alternatives which may be followed:

1 The simplest way would be to use a circular drum the stress in which can be readily computed.

2 Stays could be run between the two sheets forming the drum, the stays being proportioned so as to stay the sheets as flat surfaces.

3 A full-size section with tubes attached could be tested hydrostatically in accordance with Par. 247 of the Code. Should such a test be made the hydrostatic pressure should be applied and released at successively increasing pressures to induce a breathing action. The lowest pressure that will cause the breathing action to produce a permanent set of a magnitude to indicate that the metal has been stressed beyond the yield point, should be determined. Should such tests be made the Boiler Code Committee will be pleased to appoint a representative to witness the same and will specify the maximum allowable working pressure on the basis thereof.

CASE NO. 443

Inquiry: a An interpretation is requested of Par. H-51 of the Heating Boiler Section of the A.S.M.E. Boiler Code, in its application to the capacity requirement for water-relief valves. Was it not the intent of the second sentence, in specifying the set pressure of 15 lb. per sq. in., to refer to safety valves for use on steam-heating boilers, so that by inference it will be permissible to rate water-relief valves at $33^1/_3$ per cent above the set relieving pressure, whatever that may be, up to 160 lb. per sq. in. allowed for hot-water boilers by Par. H-3?

b Also, information is requested as to the method of application of the three right-hand columns in Table H-7 to water-relief valves. Is it understood that the rated capacities in gallons per hour apply to the heating capacities of the boilers and not to the discharge capacities of the water-relief valves?

Reply: a It is the opinion of the Committee that in referring, in the second sentence, to the set relieving pressure of 15 lb. per sq. in., it was the intent that this set pressure should refer to safety valves for use on steam-heating boilers only. For water-relief valves the capacity requirements of Tables H-7 and H-11 are applicable for set pressures not exceeding 160 lb. per sq. in.

b The values in the three right-hand columns of Tables H-7 and H-11 pertain to the heating capacities of different sizes of hot-water heating or hot-water supply boilers and do not apply to the discharge capacities of relief valves. It is the opinion of the Committee that if relief valves of the sizes indicated in Tables H-7 and H-11 are applied to hot-water heating boilers or hot water supply boilers of the various capacities therein tabulated, safe operating conditions will be obtained provided the relief valves meet the requirements of the Code.

CASE NO. 444

Inquiry: In the flanging of stayed heads for boilers, is it the intent of the Boiler Code that the same specifications for the corner radius of the flange shall be applicable as are found in Par. 194 relative to the construction of domes?

Reply: There is no rule in the Boiler Code which applies specifically to the corner radius of the flange of flat or stayed heads.

CASE NO. 445

Inquiry: In the construction of a vertical water-leg type of low-pressure boiler, with furnace extending the full height of the shell and the upper part of which furnace is filled with pipe coils for the heating surface, what formula is applicable for the calculation of the thickness of the inside or furnace sheet of the water leg, and is it necessary that the inside shell be staybolted when it is 40 in. or over in inside diameter?

Reply: There is nothing in the Low-Pressure Heating-Boiler Section of the Code to cover the calculation of the furnace sheet of this type of boiler. It is the opinion of the Committee, however, that if the rule in the Power Boiler Section of the Code for Adamson-type furnaces (Par. 242) be applied to this construction, using 30 lb. per sq. in. as the maximum allowable working pressure, safe construction will be obtained. If the length of the furnace sheet of the water leg does not exceed 6 diameters, between the supporting girth joints at opposite ends, it is the opinion of the Committee that staybolting will not be required for low-pressure heating boilers.

Seasonal Storage of Coal

Summary Report of the Storage of Coal Committee of the Federated American Engineering Societies—Purpose, Scope, Findings, and Recommendations

IN THE early part of 1923 the Administrative Board of the American Engineering Council authorized the appointment of a Committee on Storage of Coal to investigate the seasonal storage of coal and the effect of such storage in stabilizing the industry. The committee as appointed included W. L. Abbott, chairman; H. Foster Bain, William H. Blauvelt, O. P. Hood, W. H. Hoyt, W. J. Jenkins, David Moffat Myers, Edgar S. Nethercut, S. W. Parr, P. F. Walker, and Roy V. Wright.

The Committee held its first meeting in Washington, D. C., May 25, 1923, when it formulated its objective and method of procedure. The committee endeavored to secure data relating to every detail that in any way had an important bearing on the problem. The period selected for study extended from April, 1922, through March, 1923, as the coal year is generally considered as beginning in April.

An extension field organization, consisting of 67 sub-committees, was formed to secure information that should be nationally representative. In round numbers 400 individual engineers served on these sub-committees. The reports of the sub-committees were supplemented by a questionnaire sent to representatives of industries generally and a thorough search the staff of the American Engineering Council of all literature bearing upon storage of coal.

The following excerpt from the summary report prepared by the committee from the complete report sketches briefly the situation and the purposes of the investigation and gives the constructive and very important conclusions reached by the committee.

THIS report on an engineering survey of the possibilities of improving the method of procuring and storing coal should appeal to producers, carriers, and consumers as the key to the solution of many of their troubles.

The operation of the coal industry is probably beset with more difficulty than any other of the great American industries, due to prevailing intermittance of operation. If this evil could be removed it is plainly evident that a tremendous step would be taken in regularizing the coal industry and in helping other industries which are partially or wholly dependent on coal. The solution undoubtedly lies in greater storage. A reasonable accumulation in storage will permit of more even production throughout the year, deflation of the coal industry, continuous employment of labor, relief of congestion on railroads during their maximum demand season, and removal of the coal "feast or famine" conditions among consumers and many other allied troubles that are now felt as coal takes its course from mine to point of combustion. The fears of loss by the consumer have been studied by the committee and largely dispelled.

In the past the operators have said that storage is the duty of the railroads, whereas the carriers have contended that it is the duty of the consumer, and as a result storing has been neglected. This cycle must be broken, and a unified, economically sound practice established. The report wisely recommends and urges that the consumer, potentially the largest benefactor, should apply the needed balance wheel through himself initiating storage.

JOHN HAYS HAMMOND.

(Foreward to Coal Storage Report)

Summary Report of Committee

AT frequent intervals American industry and commerce experience serious interruptions and sustain grave losses because of an inadequate coal supply. Parallel with this condition the coal industry is in an unstable and hence uneconomic situation. No one group associated with the production, transportation, or consumption of coal is solely responsible for the ills that have sorely affected the coal industry, and no one of them unassisted, can effect the cure. Coöperation in action, based on mutual recognition of the benefits to be realized by each group through stabilizing the coal industry, is the only foundation on which remedial measures may succeed. But it is the coal consumer who must start the cycle that will bring about a stabilized industry. The producer of coal the carrier, and the public official collectively are helpless without the active aid of the consumer. In the last analysis it is the consumer that will profit most by any improvement in coal procurement.

Effect on Industries of Fluctuating Coal Demand

American industry is vitally affected by interruptions in coal production and transporation in other ways than through the consequences of a fluctuating coal market. In many manufacturing processes continuous operation is essentially important. The consequences of inadequate supply and inferior quality of coal for these processes are often very grave. Furthermore, the necessary curtailment of production for want of coal disarranges purchasing, sales, and fiscal plans. Industry is also concerned with the proper functioning of the country's transportation agencies, which deliver to industry its raw materials and distribute its finished products. Hence a stabilization of the load factor of the railways is of the utmost importance to American industry. The movement of coal in late fall and early winter, overlapping as it does the shipment of agricultural products, has repeatedly resulted in transportation delays. Industry has lost far more through such causes than through the fluctuation in coal prices themselves.

Remedy for Uncertain Coal Supply

In this report a simple and practical remedy is set forth whereby the consumer may eliminate uncertainties regarding the quantity and quality of his coal supply. Its adoption will require no radical changes. It will entail but a slight increase, if any, in the consumer's annual coal bill. Eventually, with the general adoption of the method proposed, his coal bill will be materially lessened through a reduction in production and transportation costs due to stabilization.

The method recommended is the seasonal storage of coal by consumers.

The report discloses that seasonal storage by the consumer is an essential and necessary step toward stabilizing the procurement of industrial coal. It is an economic and practical means of insuring an adequate supply and satisfactory quality of coal when needed. The report shows further that through a general and regular practice of storing coal many ills attending coal production may be eliminated.

The irregularity in coal production is largely due to seasonal demand. Since more coal is consumed in the late fall and in the winter than at other periods, coal producers and carriers each year are confronted alternately with a feast and a famine—with an inordinate demand for coal and transportation, followed by a period of no demand. This seasonal demand is responsible for 47 per cent of the idle time of the coal industry.

Effect in Coal Industry of Seasonal Demand

Seasonal demand also contributes to another very disturbing element: namely, the overdevelopment of mine capacity through opening too many mines. Coal production capacity is not twice as large as the consumption capacity. The two factors—intermittent or seasonal operation and overdevelopment—are in a very large measure responsible for the ills of the coal industry.

Seasonal Storage of Coal

Among the numerous solutions for the coal problem, extending as far as strict governmental regulation and even governmental ownership and operation, which have been proposed, or given con-

sideration by Congress the United States Coal Commission, and other bodies, the project of seasonal storage of coal has naturally received much attention. While, however, there has grown up a large amount of information relating to coal storage, the information has never been brought together and properly analyzed, interpreted, and disseminated for use. Advocates have contended that a larger use of the practice of storing coal on the part of producers, dealers, and consumers would materially relieve the intermittent aspect of the coal industry; would result in an ample coal supply at all times; would reduce peak demand upon and facilitate a more economical use of transportation facilities; would permit a larger reliance upon water transportation; would reduce mine operation costs and transportation expense; and would lead to reduction in the cost of coal to the consumer. On the other hand, there have been emphatic declarations that the storage of coal is impracticable because of the financial burden involved, danger from spontaneous combustion, degradation due to breakage, and loss of heat value and deterioration of firing qualities. In the absence of any authoritative statement in the matter the consumer has had no adequate guide in determining his own policy regarding the storage of coal, and no uniform or general practice has been followed.

ACTION BY AMERICAN ENGINEERING COUNCIL

Consideration of the vital importance of the coal situation to industry, and particularly the thought of the possibilities offered by storage, promoted the American Engineering Council, in the spring of 1923, to undertake, through its Administrative Board, a comprehensive study of coal procurement and storage.

It was thought that an analysis and interpretation of the best and most authoritative information regarding the storage of coal would correct many false impressions associated with the subject. Furthermore, it was believed that by the presentation of facts relating to the engineering, chemical, and economic phases of the subject, there would follow an improved condition in the operation of the coal industry and those utilities and industries where coal is the source of power and heat. Accordingly the Administrative Board of the American Engineering Council at a meeting held in Cincinnati, Ohio, March 23 and 24, 1923, officially authorized the appointment of a Committee on Storage of Coal to make a comprehensive study, and approved an outline to guide the investigation.

The committee appointed was composed of 11 men versed in the following factors appertaining to coal: its mining transportation, engineering, chemistry, combustion, large- and small-scale storage distribution, financing, and the several relationships of these factors.

ATTITUDE OF UNITED STATES COAL COMMISSION

In regard to the storage of coal and the Council's investigation thereof, the United States Coal Commission stated in its report of September, 1923:

> As has been repeatedly shown in these reports, the peak demand for coal involves a peak demand for coal transportation too acute to be adequately met by the railroads, except by an unwarranted expansion of rail equipment and facilities. The removal of the peak therefore appears to be the direct remedy, and the consumer can contribute to the removal of the ups and down of the coal business by buying for regular delivery and balancing seasonal variations in consumption by storage.
>
> Storage of coal by consumers is the balance wheel between fluctuating consumption and variable production. Regular, systematic, large-scale storage of bituminous coal, then, is the public's largest opportunity in helping to solve the coal problem, and the consumer's responsibility may be said to be proportionate to his annual requirements. It is especially gratifying, therefore, that the railroads, the public utilities, the iron and steel industry, and other large users of bituminous coal in the United States have undertaken storage on a large scale. The definite adoption of this policy by the larger railroads and public utilities is plainly in the public interest, and never before has the outlook been more promising for the continuation an extension of this direct method of stabilizing coal production. We commend also the present activity of the American Engineering Council in promoting the storage of coal by practical investigation and popular education.

FINDINGS OF STORAGE OF COAL COMMITTEE

The committee presents the following findings and recommendations as to:

1 Production and distribution of coal in the United States
2 Extent of the practice of storing coal
3 Methods and equipment of storage plants and the physical and operating problems involved
4 Coal required by localities, and advantageous points of storage
5 Transportation problems
6 Cost of installing and maintaining coal-handling and storage equipment
7 Cost of actual storage, including problems of finance, insurance, and taxation.

A careful analysis of the information obtained and herein presented brings out the following important findings:

1 The storage of coal is essentially necessary as an aid to the solution of the national coal problem, and is an economic and practicable means of insuring an adequate supply of coal as needed.

2 If each coal consumer will adopt the policy of annually purchasing coal on a uniform monthly delivery basis, there will result automatically sufficient seasonal storage to guarantee coal to the consumer, as needed. Furthermore, this policy will bring about a uniform demand for coal whereby the coal producer and carrier may establish uniform and standard production and shipment schedules. It will also remove the evils of intermittent coöperation of coal mines, frequent panicky market conditions, and coal shortages due to inability of the carriers to meet peak demands.

3 The amount of storage required to produce these corrective and constructive results is small in terms of the per cent of annual consumption. For seasonal storage, from 9 to 10 per cent of the annual consumption is all that is required. If this amount is supplemented by additional reserve storage of no more than 7 per cent, there will result an accumulation of some 83,000,000 tons of coal in storage by September 30 of each year. The practicability of this amount of storage with but slight additional outlay for equipment is indicated by the fact that in September, 1923, 56,000,000 tons were in storage.

4 Equipment has been developed and may be secured to meet any storage situation or requirement. The cost of such equipment ranges from a few cents per ton of capacity up to $2.50 or $3.00 per ton of capacity.

5 Storage of coal presents no serious risk of loss from breakage, spontaneous combustion, or loss of heat value or firing qualities. All kinds of coal have been and may be successfully stored. The insignificant money loss due to the factors named above should not deter any one from storing coal. Application of the simple and inexpensive regulations and practices set forth in this report will provide all reasonable safeguards against such possible losses.

6 The cost of storage per ton, including fixed charges on equipment, maintenance, and operation expense and interest on investment in coal as well as taxes and insurance in most instances does not exceed 75 cents per ton yearly; more generally it is around 50 cents. This cost is insignificant when distributed over annual consumption.

7 Storing of coal may be easily financed. Banks will finance such an investment as readily as any other commercial undertaking.

8 The transportation facilities of the United States are adequate for normal and regular movement of coal. For short periods the railways can move coal at an abnormal rate, but this is both expensive and detrimental to shipment of other commodities and tc normal freight movement.

9 To increase transportation facilities to meet the peak demands resulting from the prevailing unsystematic practice in coal shipment would require an additional investment of some $12,000,000,000. Such an investment is not justified.

10 The railroads have more to gain by storing coal than any other class of consumer. They should store their own coal on such a scale and at such times as to obviate the movement of company or non-revenue-producing coal during the period when there is a heavy demand for the transportation of revenue-producing freight. They should abandon, however, the uneconomic practice of using freight cars for storing coal and thereby withholding railroad equipment from other uses.

11 In general, storage should take place at the point of use, to accomplish the most in relieving transportation and safeguarding supply. However, under some circumstances storage at an intermediate point is advisable.

12 In general, storage at mines is not recommended, but there should be sufficient mine storage facilities and capacity to overcome ordinary operation delays, such as belated arrival of cars, temporary breakdown, or idleness of mining equipment and the like. Such pro-

vision would materially increase the producing hours of mines and miners.

13 Cars should be assigned to mines upon the basis of coal actually sold and not upon rated capacity of production. This measure would be a wholesome deterrent to overdevelopment of coal-producing facilities.

14 While this study refers primarily to industrial consumers of bituminous coal, yet householders have also a direct responsibility. Indeed, the householder is in a position to aid with the least cost, because no special equipment for storing and reclaiming is required and his individual investment in coal is relatively small. Householders use approximately 50,000,000 tons of bituminous coal annually, which, if placed in their bins by the end of September of each year, would materially contribute to the solution of the coal problem.

15 Federal state, city, and other civic divisions of the body politic are meeting their responsibility in relation to the seasonal storage of coal. They are as derelict in regard to seasonal storage as are other users, and frequently add to a confused situation by securing priority orders. Public officials should take the lead, by precept and by example, in furthering the storage of coal.

16 Contracts for coal should be observed with fidelity. The evil practice of indiscriminate breaking of coal contracts has seriously injured the American coal industry with reference alike to production, transportation, and consumption. Contracts for coal should be observed with the same good faith as universally prevails in regard to other forms of commercial contracts.

17 Confirmation of the practicability of coal storage is afforded by the anthracite-coal industry. This industry is far more stable than the bituminous, because producers, carriers, and consumers of anthracite coal for a number of years have alike encouraged and practiced storage.

COMMITTEE RECOMMENDATIONS

The committee recommends and urges that all coal consumers purchase their coal on an annual contract for yearly requirements with a provision that the coal be delivered monthly in equal allotments. The committee further recommends and urges that consumers provide necessary storage facilities to meet the terms of such contract. These recommendations are based upon the finding that the purchase of coal upon a uniform monthly delivery basis will result in a condition whereby:

1 Coal mines may inaugurate and maintain a regular production schedule
2 Carriers may plan definitely as regards both schedules and equipment for a uniform movement of coal
3 Stocks of coal automatically will accumulate during the months from April, to September, inclusive, in sufficient amount to meet the extra consumption during the winter months
4 A reduction in the price of coal will be made possible by more regular schedules of production and transportation and by elimination of peak demands in the winter months when the costs of both production and transportation are the highest.

The committee reiterates that the coal consumers through seasonally storing coal can and should initiate this vitally necessary cycle of changes.

The Energy in the Atom: Can Man Utilize It?[1]

DISCOVERY of extensive, convenient, and dependable sources of cheap energy is a growing need of advancing humanity. Increasing knowledge of the structure of matter raised hopes in the breasts of scientists and laymen alike that within the atoms were stores of energy, almost inconceivably great, which science would some day learn how to put at the service of mankind.

The important question of the energy relations involved in the formation and disintegration of atomic nuclei was first opened up by the study of radioactivity. For example, it is well known that the total evolution of energy during the complete disintegration of one gram of radium is many millions of times greater than in the complete combustion of an equal weight of coal. It is known that this energy is initially mostly emitted in the kinetic form of swift alpha and beta particles, and the energy of motion of these bodies is ultimately converted into heat when they are stopped by matter.

Since it was believed that the radioactive elements were analogous in structure to the ordinary inactive elements the idea naturally arose that the atoms of all the elements contained a similar concentration of energy, which would be available for use if only some simple method could be discovered of promoting and controlling their disintegration.

It is quite true that, if we were able to hasten the radioactive processes in uranium and thorium so that the whole cycle of their disintegration could be confined to a few days instead of being spread over thousands of millions of years, these elements would provide very convenient sources of energy on a sufficient scale to be of considerable practical importance. Unfortunately, although many experiments have been tried, there is no evidence that the rate of disintegration of these elements can be altered in the slightest degree by the most powerful laboratory agencies.

It may be that the elements, uranium and thorium, represent the sole survivals in the earth today of types of elements that were common in the long-distant ages, when the atoms now composing the earth were in course of formation. A fraction of the atoms of uranium and thorium formed at that time has survived over the long interval on account of their very slow rate of transformation.

It is thus possible to regard these atoms as having not yet completed the cycle of changes which the ordinary atoms have long since passed through, and that the atoms are still in the "excited" state where the nuclear units have not yet arranged themselves in positions of ultimate equilibrium, but still have a surplus of energy which can only be released in the form of the characteristic radiation from active matter. On such a view, the presence of a store of energy ready for release is not a property of all atoms, but only of a special class of atoms like the radioactive atoms which have not yet reached the final state for equilibrium.

On the other hand, another method of attack on this question has become important during the last few years, based on the comparison of the relative masses of the elements. This new point of view can best be illustrated by a comparison of the atomic masses of hydrogen and helium. It seems very probable that helium is a very close combination of four hydrogen nuclei and two electrons. On modern views there is believed to be a very close connection between mass and energy, and the loss in mass in the synthesis of the helium nucleus from hydrogen nuclei indicates that a large amount of energy in the form of radiation has been released in the building of the helium nucleus from its components.

It is easy to calculate from this loss of mass that the energy set free in forming one gram of helium is large even compared with that liberated in the total disintegration of one gram of radium.

It must be acknowledged that these arguments are somewhat speculative in character, for no certain experimental evidence has yet been obtained that helium can be formed from hydrogen.

The evidence of the slow rate of stellar evolution, however, certainly indicates that the synthesis of helium, and perhaps other elements of higher atomic weight, may take place slowly in the interior of hot stars.

Our information on this subject of energy changes in the formation or disintegration of atoms is as yet too uncertain and speculative to give any decided opinion on future possibilities in this direction.

[1] Sir Ernest Rutherford, President, British Association for the Advancement of Science, in one of a series of research narratives published by Engineering Foundation.

Screw-Thread Standard Now Ready

A PAMPHLET giving the American Standard Screw Threads for Bolts, Machine Screws, Nuts and commercially Tapped Holes is now ready. It contains tables, information, etc., selected from the Progress Report of the National Screw Thread Commission and presents sufficient information for the use of manufacturers and users of screw threads. The Report, which was approved by the American Engineering Standards Committee in May, 1924, is sponsored by the Society of Automotive Engineers and The American Society of Mechanical Engineers, and may be purchased from the last named Society at 29 West 39th Street, New York.

Power Generation in the Modern Steel Works

BY G. R. McDERMOTT,[1] SOUTH CHICAGO, ILLINOIS

THE quantity of gas produced from a 550-ton furnace at the coke rate of 2000 lb. is distributed approximately as follows:

	Cu. ft. per day millions	B.t.u. per hr. millions	Per cent
Required for the blast-furnace stoves	26.6	103	35
Consumed by gas blowing engines	7.6	29	10
Losses	3.04	11.8	4
Surplus available for steam electric power generation	38.76	150.7	51
Total	76.00	294.5	100

A steel plant with six blast furnaces installed and in operation will therefore produce gas for the generation of power at a rate of 9.66 million cu. ft. per hr. while all furnaces are active, or at a rate of 7.92 million cu. ft. per hr. while one of the furnaces is casting.

The gas as it is delivered from the blast furnace contains dust which should be removed before it is used in the stoves, boilers, and gas engines.

The gas used as fuel for the blast-furnace stoves and steam boilers passes through primary washers only, while that used for the gas blowing engines and for gas-electric power engines passes also through secondary washers. Starting with the cleaned gas, the alternatives are steam generation, using steam in engines and turbines, or using the gas in internal-combustion engines. The overall efficiency from fuel to power generated is in favor of the gas engine, as the thermal efficiency of such units will average 24 per cent for a month's period based on power delivered at the switchboard. The available gas from the plant of six furnaces will thus permit the continuous generation of 50,000 to 60,000 kw., although the steel-mill load for this plant will probably only average in the neighborhood of 25,000 kw.

The open-hearth furnace is the next link in the chain of units which consume large quantities of fuel. The efficiency of a well-designed furnace is about 17 per cent. Of the losses, 55 per cent is represented in the sensible heat of the waste gases which are discharged from the furnace stack. By the installation of a waste-heat boiler and economizer about 45 to 50 per cent of the stack losses may be recovered in the form of steam. The pig-iron product from six blast furnaces would produce 1.75 million tons of steel per annum, and assuming that 65 per cent of the material charged into the open-hearth furnaces is hot metal from the blast furnaces, this production would require an installation of twenty-six 100-ton open-hearth furnaces. The temperature of the waste gases at the stack of the furnace varies from 1100 to 1300 deg. fahr., and the steam generated would represent approximately 13,000 b.hp.

While on the subject of steam generation from waste gas, attention should be drawn to the sensible heat contained in the exhaust gases of a modern gas engine. This energy is probably equivalent to between 35 and 40 per cent of that developed by combustion in the cylinder. The temperature of the waste gases near the exhaust valve is about 950 deg. fahr. and by the installation of a fire-tube boiler designed along the lines of a waste-heat boiler for open-hearth furnaces, it is possible to generate 2.25 lb. of steam at 250 lb. pressure per kilowatt generated by the gas engine. The cooling water from the gas engine may be used as feedwater for such a boiler. Based on a 25,000-kw. load, the waste-heat steam from gas-engine exhaust would generate 3750 kw. by means of a turbo-generator having a water rate of 15 lb. per kw-hr. The gross thermal efficiency from fuel to switchboard has thereby been increased from 24 to 27 per cent.

The remaining important link is the rolling mills. The main rolls and auxiliary drives of the modern plant are motor driven. A steel plant of the capacity outlined would require about 25,000 kw. average, with momentary peaks amounting to 35,000 kw.

Summarizing, in a well-designed steel plant utilizing the waste heat as described, it is possible that the bulk of the coal would be consumed at the by-product coke ovens for the making of coke for the blast furnaces. The steam generated by the utilization of the sensible heat in stack gases and gas-engine exhaust would be available for miscellaneous purposes and for electric power generation by turbo-generators installed to assist the gas-driven generators and thus form an elastic combination for absorbing the fluctuating demands from the rolling-mill motors. As has been indicated above, there will be a surplus of blast-furnace gas over and above that required for electric-power generation. Such surplus may be used in combination with producer gas generated from waste coke for heating the coke ovens themselves, thereby increasing the surplus of coke-oven gas for melting in the open-hearth furnaces and elsewhere.

[1] Mechanical Engineer, Illinois Steel Company.

Presented besore the Chicago Local Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Jan. 15, 1924.

Power Problems of the Steel Industry

(*Continued from page 462*)

flow engine was a 100 per cent investment, i.e., the cost of installing the new engine was repaid by the fuel saving in twelve months.

So far as Professor Trinks had been able to learn, the savings resulting from the electrification of existing steel plants were less than one-half of what they were when uniflow engines were installed. It should be distinctly understood that these remarks referred to existing plants only, and not to new installations.

Bryant Bannister, who opened the oral discussion, as an example of the savings that could be effected by attention to the smaller details cited the equipping of a certain 1500-hp. steel-works boiler with an automatic regulator at a cost of $250, which enabled a saving of $17,000 to be made in one year.

B. M. Herr,[1] referring to the author's statement that the coal required in the steel industry to produce a brake horsepower-hour was 4.3 lb., said that it was quite common in central-station practice to generate a kilowatt-hour on 1.4 lb., and that it was difficult to see why a similar result should not be obtained by the steel companies as they were such large consumers of coal. Mr. Skinkle had pointed out that there were probably nine different kinds of fuel used in the steel industry, and it would seem to be indicated that their engineers should use their ingenuity and ability in developing the economical burning of other fuels and leave the supplying of current generated by burning coal to the central stations.

F. M. Van Deventer, referring to Mr. Bannister's remarks regarding savings made by giving attention to small details, said that large losses of steam occurred through leaky valves and traps. Similarly, a test of the compressed-air system of the plant with which he was connected had shown that about twice as much air was being compressed per week as was being used. It was necessary for some one to devote the largest part of his time to running down such losses, for examination and correction at infrequent intervals was not enough.

M. G. Benjamin[2] said that there were possibilities in the matter of regulation of combustion in steel plants that were not ordinarily realized by most operating engineers. The fact that variations in load and that variations in output of different boilers could be smoothed out by mechanical and automatic operation, in itself meant that the effect of a more nearly constant load could be obtained, which made it possible to get a better ratio of fuel and air and thereby a higher combustion efficiency.

Mr. Hunter, in closing, said that his statement to the effect that the turbine seemed to be replacing the large gas engine, to which Mr. McDermott had taken exception, was meant for a general statement applying to the entire industry. The Illinois Steel Co. was one of the few companies that were continuing to install large gas engines.

With the present price of coal the recovery of waste heat from the exhaust gases from gas engine, from heating furnace flue gases, etc., except in a few cases, would not make enough saving to justify the cost of equipment for its recovery.

As stated by Messrs. Bannister, and Van Deventer, there were possibilities for quite large savings in most steel works by stopping relatively small leaks and wastes.

Installing of automatic regulating equipment as discussed by Messrs. Van Deventer, Bannister, and Benjamin, had many advantages in smoothing out loads, and in most every case would show a large return on the investment.

[1] Herr, Harris & Co., Pittsburgh, Pa. Mem. A.S.M.E.

[2] Pres., Benjamin Engineering Co., Cleveland, O. Assoc-Mem. A.S.M.E.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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More About Hardness

THE more one studies the subject of hardness, and especially the meaning of the term "hardness," the more he comes to the conclusion that to all practical purposes in our present state of knowledge, hardness is "all things to all men." As has been repeatedly stated before, the hardness measured by the Brinell method is not the hardness measured by the Shore scleroscope and again not the hardness measured by the scratch test, neither is it quite the hardness measured by the Herbert pendulum nor that measured by the rolling wear test or the modified scratch hardness as measured by the Bierbaum microcharacter.

In a recent book on the Strength and Structure of Steel and Other Metals, Prof. W. E. Dalby, of the London Imperial College of Science and Technology, asks, "What is hardness? Is it a single quality of material which can be measured by a single test?" There is no difficulty in understanding what hardness is. A workman has clear ideas on the subject. He knows that tool steel hardened will cut most metals. He knows that a blunted steel tool can be sharpened on a corundum wheel. And he knows that corundum can be turned with a diamond-pointed tool as easily as wood can be turned with a steel tool. Diamond, corundum, hardened tool steel, other metals, stand to him in a scale of hardness, completely understood.

The difficulty is to find a form of words which will define hardness, because hardness is a property which is a sum of other properties. Hardness is related to other properties and cannot be defined without reference to them any more than the strength of a material can be defined in absolute terms.

The situation is still more confused by the fact that in addition to the physical conception of hardness there is the old mineralogical Moh scale of hardness where all minerals are divided into ten classes in accordance with their ability to scratch or be scratched by certain "scale minerals."

It is a question under these conditions whether the use of the term hardness by engineers helps to clarify or confuse the situation as after all it does not mean anything definite or tangible today to those who wish to use engineering terms correctly and gives an impression of having a definite meaning which it really does not to the general public, both in and out of engineering circles.

Might it not be advisable under these conditions for the time being and until a definite physical conception of hardness has been established and universally adopted, to drop entirely the use of this term and to speak of Brinell numbers, Herbert numbers, etc., rather than of Brinell hardness? The expression "Brinell number" has a very definite meaning. It means a number on the scale obtained by a Brinell test. Just what property of the material this denotes we now know with a precision sufficient for all practical purposes and there is no confusion about this meaning. Furthermore, the use of the expressions "Brinell number" and "Shore scleroscope number" is definite and does not create the confusing impression that in some way the two are equivalent or translatable into each other as do the expressions "Brinell hardness" and "Shore scleroscope hardness," the fact being that the two are neither equivalent to each other nor, strictly speaking, even translatable into each other, as has been recognized by the U. S. Bureau of Standards.

There is another matter in connection with the measurement of hardness to which probably less attention is being paid than should be, and that is the determination of the extent to which the measurement of the surface layer indicates the property of the body. As a matter of fact, hardness has been defined as "the resistance of a surface against deformation by mechanical means." This definition has a very clear physical meaning, provided by surface is understood the outer layer, and this brings the question—"What thickness of surface layer should be taken as determining the hardness of a body?" In many cases this is not important, because only the hardness of the surface layer comes into consideration or because presumably there is no difference between the hardness of the exterior skin and the interior core. The first condition is found, for example, and in the case of chilled rolls, and the second in machined steel forgings and in wrought iron. There are, however, cases where neither of these conditions obtain as, for example, in the case of unannealed steel castings, which may have quite a hard skin and a soft understructure; and when such castings are machined this difference between the working properties of the outer skin and inner body of the material becomes very noticeable.

Rational Standardization

A RATIONAL method of selecting sizes and styles of commodities that will reduce varieties with consequent reduction in production costs will always be received enthusiastically when its possibilities are proven and its rationality demonstrated. Such a method, developed and discussed in France and Germany, was placed before the industries of this country by C. F. Hirshfeld and C. H. Berry in their paper on Size Standardization by Preferred Numbers at the 1922 Annual Meeting of The American Society of Mechanical Engineers.

In the correspondence column of the July issue of MECHANICAL ENGINEERING there was a discussion by C. C. Stutz on the subject of preferred numbers and in this issue C. F. Hirshfeld and C. H. Berry reply to the questions which Mr. Stutz asks about this method of ordering our course of rational standardization. The discussion should lead to further careful study by designers of some system of preferred numbers or geometrical progressions to determine the actual economies that can be secured in the manufacture of some particular product. While Messrs. Hirshfeld and Berry emphasize the value of discussion from engineers not actually engaged in production, in the last analysis real information as to the value or lack of value of any scheme of preferred numbers can be obtained only by those who study their own product with some system of preferred numbers in mind.

Mr. Stutz pointed out that the use of geometrical progressions for determining sizes is old and Messrs. Hirshfeld and Berry indicate that the preferred numbers series was studied and applied in France in 1879, but the underlying principles of some such scheme for selecting sizes have not been generally understood. An example of this is the A.S.M.E. Standard for Pipe Flanges, published in 1914, which gives standard dimensions for sizes of pipe flanges from 16 inches to 100 inches by increments of two inches. Of course no manufacturer has ever made or sold that many sizes. The Sectional Committee on the Standardization of Pipe Flanges and Fittings appreciates the futility of so many sizes and in their present work will undoubtedly be able to eliminate many sizes, with a consequent saving in jigs, fixtures, and patterns.

Transcontinental Airplane Communications

TWO outstanding achievements in the history of American aviation were brought about in July, 1924, namely, the dawn-to-dusk flight from New York to San Francisco by Lieut. Russell Maughan under the auspices of the Air Service, War Department, and the establishment of regular mail service by air between the Atlantic and Pacific seaboards.

The regular operation of airplane service over a distance of 3700 miles, a large section of which is still practically open country, required an enormous amount of organization and executive ability. The Post Office Department has had several years' experience in the carrying of mail over shorter distances, and has undoubtedly made excellent use of the data which it has collected during that time.

That acceleration in the transportation of mails between San Francisco and New York—including intermediate points—is of great importance to the present life of the country, needs of course no proof. But the technical difficulties involved in providing facilities for night flying have been very great, and it should be remembered that what the Post Office Department undertook to do and will undoubtedly achieve is not a few flights in good weather, but regular and reliable service in all kinds of weather and under all sorts of conditions.

It is a significant fact that in the last year or two the development of mail transportation has been such as to insure regular and reliable delivery of mails with a remarkably small percentage of accidents, particularly when one considers that the mail pilots have to fly in all kinds of weather over several routes noted for the uncertainty of their atmospheric habits.

During the present summer a number of flights have been made which bear testimony to the high state of development already attained by modern heavier-than-air aircraft. The French lieutenant, D'Oisy, flew in a standard military machine from Paris to Indo-China with only scant facilities for engine overhaul. The American round-the-world fliers successfully braved in the same machines the Arctic fogs and snows and the heat of southern China and India. Only a few days ago a German flier covered the distance between Berlin, Germany, and Aleppo, Turkey, while flights of 1000 miles have become so common as to attract practically no attention.

The Three-Cylinder Locomotive

AMERICAN railroads have had to contend with a very difficult problem—that of carrying a stupendous and constantly growing traffic over systems the mileage of which has been to all practical purposes stationary for more than 15 years.

This problem was met by the use of freight cars of gradually increasing size, but the use of such cars, in turn, made it imperative to increase the size of locomotives to the point where they could handle trains of formerly unheard-of weights.

The locomotive grew in every direction, and in some types it ultimately became so bulky as to leave the minimum possible clearance when going through tunnels. Furthermore, the increase in the size of the locomotives raised the stresses produced in the rails and roadbed to such an extent as to place a limit to further development of railroad tractive power along conventional lines.

In the meantime important improvements were introduced in the steam locomotive in other directions, such as the thermic siphon, the booster, feedwater preheating, and mechanical stoking. The three-cylinder locomotive with its ability to deliver a high tractive effort in a manner that does not correspondingly increase the hammer stresses in the rail or roadbed is a further step in the development of a steam locomotive that will be capable of coping with the difficult rail-transportation problem of today.

It is also one more reminder of the fact that the steam locomotive as the cardinal factor in rail transportation in America is developing an increasing vitality. There are many avenues of improvements open to the steam locomotive, some of which are already available, as, for example, the use of higher pressures, and more powerful and more economical locomotives will contribute to the solution of our transportation problems long before a far-reaching electrification program can be achieved.

A.S.M.E. Annual Meeting and the Power Show

THE program for the Forty-fifth Annual Meeting of The American Society of Mechanical Engineers is well under way. The dates are December 1 through 4, and the place will be the Engineering Societies Building in New York. All of the technical programs have been submitted by the Professional Divisions of the Society, and the authors are at work preparing their papers which must be in hand by October 1 in order to be printed and issued previous to the meeting to secure well-considered discussion. The Committee on Meetings and Program is keenly anxious that every opportunity be given for discussion, for therein lies the strength of a meeting. As a good discussion requires time and thought for its preparation, the necessity for having the papers ready well in advance is obvious.

The topics to be considered at the technical sessions include lubrication, hardness of metals, oil burning, oil storing and handling, resuperheating in the steam turbine, pulverized fuel, scale formation in boilers, the solid-injection oil engine, ordnance manufacture, the development of spinning and twisting, turbo-locomotive practice, general machine-shop problems, and management.

The Third National Exposition of Power and Mechanical Engineering will be held in the Grand Central Palace, New York City, from December 1 through December 6, 1924, the same week that the A.S.M.E. meeting is held. It also parallels the meeting of the American Society of Refrigerating Engineers. These organizations, as well as the American Society of Heating and Ventilating Engineers, are represented on the Advisory Committee for the Power Show. The A.S.M.E. delegation consists of the President, Fred R. Low; the Chairman of the Professional Divisions Committee, James Partington; the Chairman of the Power Division, Nevin E. Funk; and the Secretary, Calvin W. Rice. The A.S.R.E. is represented by its President, George V. Horne, and the A.S.H.V.E. by Homer Addams, President.

Over two hundred and fifty concerns have signified their intention of exhibiting at the coming event and there is now little space available on the first and mezzanine floors. It is contemplated that the third floor will also be required for the coming event. The attendance at the second exposition was 62,079 representative engineers, operating men, executives, and financiers as well as technical students and instructors. Comparing this with the attendance of 47,580 for the previous year is ample indication that the Exhibition fills a needed place.

Europe an Engineering Mecca This Summer

EUROPE has been a special attraction to American engineers this summer with the engineering conferences and exhibits at London and Prague during July and the excellent opportunities offered those who crossed the Atlantic to witness the recent developments made in engineering and industry. A large group of engineers attended these conferences from the United States and Canada, the main body sailing from New York on the S. S. *Scythia* on June 19.

The British Empire Exhibition at Wembley, near London, furnished the background for a number of interesting events. Of the greatest value to engineers was the World Power Conference, which lasted from June 30 through July 12. Participated in by seventeen countries, it had for its purpose the consideration of the potential power resources of each country and the discussion of various problems of power development and utilization. The conference was supplemented by a large number of entertainments extended to American engineers by the British Institutions of Civil, Mechanical and Electrical Engineers, among them being the presentation of the Kelvin Medal to Prof. Elihu Thomson on Thursday, July 10.

The second important function during July was the International Management Conference held in Prague, Czechoslovakia, July 21 through 24. The program arranged by the Committee on American Participation included a discussion on Scientific Management, Budget Control, Production Management, Sales Management, Management in the Coal Industry, Management of Transportation, Management in Government, and Education. Following the conference the delegates from America were given an opportunity to visit a large number of manufacturing plants in Czechoslovakia.

The September issue of MECHANICAL ENGINEERING will have a complete account of these events.

Selling Standards

A NOVELTY was introduced to the technical program of the Cleveland Spring Meeting in the form of informational oral reports by members of certain standardization and safety code committees of the Society. These reports were presented to the sessions of the Professional Divisions most interested in the particular committee. They were necessarily very brief, but each speaker tried to point out clearly in exactly what way a particular report prepared by his committee would be of use to the members present.

The important part of standardization and safety code committee work comes after the standards and safety codes have been formally adopted. It is concerned with putting these standards and codes in service. The procedure of the A.E.S.C., under which all A.S.M.E. standards and codes are developed and formulated, provides for full participation of all organizations which will be vitally affected by the standard when approved and for unlimited discussion from all interested parties.

When the processes of evolving a standard or code are completed, therefore, the majority of the organizations interested are completely informed through their official representatives of its contents and value. However, there are many individuals who may or may not be connected with these interested organizations who should have information at the earliest possible moment about these approved standards and codes. So steps taken by the various professional committees of the Society to inform the members by the spoken word at sessions constitute an excellent procedure.

Machine-Shop Practice

THE coming fall will bring the Fourth Annual Machine Tool Exhibition at New Haven. This event has been exceedingly popular in the past years and hearty congratulations are due the sponsors, Yale University, New Haven Chamber of Commerce, and the New Haven Section of the A.S.M.E.

The promise of interest in the coming event is heightened by the fact that the Machine Shop Practice Division of the Society has been called into coöperation for the preparation of a technical program devoted to machine-shop problems. The program planned will last for four days, September 15 through 19, and the result will be a form of meeting rather new to the A.S.M.E. In effect it will be a gathering devoted to one phase of mechanical engineering, with an excellent exhibit as a background. This should appeal strongly to the large number of members of the Society in the machine-shop field who have complained of the lack of programs devoted to their specialty. This meeting will give them an opportunity to gather for four days and enjoy the papers and the friendly association that comes with a meeting of this character.

Death of Benjamin G. Lamme

BENJAMIN G. LAMME, chief engineer of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., and one of the pioneers in developing methods of high-tension power transmission, died on July 8, 1924, at his home in East Liberty, Pa. Mr. Lamme was ranked by scientific experts with Thomas A. Edison and the late Charles P. Steinmetz, the three being generally known as the "Wizard Trio."

Mr. Lamme was born on a farm near Springfield, Ohio, on January 12, 1864. He was graduated from Ohio State University in mechanical engineering in 1888. There he excelled in mathematics, being a master of high-range multiplication tables and differential calculus. He became interested in electricity and upon his graduation entered the Westinghouse employ at thirty dollars a month. His most spectacular designing achievements were the generating equipment for the World's Fair in Chicago in 1893, the 5000-hp. umbrella-type generators which first harnessed Niagara Falls, the generating and motor equipment for the first big railway electrification on the New York, New Haven & Hartford; the most successful synchronous converter ever used, and the single reduction-gear street-car motor which, designed in 1890, is the type still used on street-railway systems.

Aside from his life work he was interested in amateur photography and had a collection of unique photographs taken all over the world. He also had a very remarkable library containing a formidable array of technical volumes side by side with detective stories and other imaginative fiction.

Mr. Lamme was a member of the American Institute of Electrical Engineers, who chose him as one of two members from that body for the Naval Consulting Board in the World War. He was chairman of the inventions committee of the Board. In 1919 he was awarded the Edison Medal, and in 1923 the Ohio State University, in conferring upon him the Joseph Sullivan Medal—an honor previously bestowed only twice (upon Edison and Steinmetz)—pronounced him "the greatest living mathematician."

Wilfred Campbell Dies

WILFRED CAMPBELL, one of the leading turbine engineers of the country and famed for his recently completed investigation of the problem of protecting steam-turbine disk wheels from axial vibration, died at his home in Schenectady, N. Y., on July 7 as a result of complications following an appendicitis operation.

Mr. Campbell was born in Manchester, England, in 1884, and came to America in 1907. In 1907 he became connected with the General Electric Company, and during the recent war was associated with Dr. Irving Langmuir and C. E. Eveleth, of the same company, in connection with research and design work on submarine detectors. Since 1919 he has been an engineer in the company's turbine department. Last December Mr. Campbell received an award from the Charles A. Coffin Foundation in recognition of his contribution to turbine research and design, the results of which were presented before The American Society of Mechanical Engineers on May 26 and will remain a monument to his energy and ability.

Wilfred Campbell

Francis C. Pratt, vice-president of the General Electric Company, in charge of engineering, in commenting on Mr. Campbell's death, made the following statement:

> Mr. Campbell's sudden death is a great shock to his many friends and associates in this company. At the time of his death he was the engineer in charge of investigation of turbine-wheel vibrations. When he undertook this important work in 1919, it was thought by some engineers that the limits in the size of individual turbine units had been reached. Mr. Campbell had a rare genius for analyzing and solving abstruse problems of a mechanical nature and did not share these adverse opinions regarding the limitations in the size of steam turbines. He discovered the cause of the troubles with large turbine wheels and buckets, devised remarkably ingenious methods of detecting and measuring the phenomena connected with them, and provided means for overcoming them. He has made a fine and lasting contribution to the industry, and his work will long be remembered by engineers who design and operate steam turbines.

Mr. Campbell is survived by his wife and four children.

1924 Commission of Washington Award to Arthur N. Talbot

THE Commission of Washington Award for 1924 was voted to Arthur Newell Talbot, University of Illinois, and the presentation was made at the annual meeting of the Western Society of Engineers, June 9, 1924. The award was made to Professor Talbot for his life work as student and teacher, investigator, and writer, and for his enduring contribution to the science of engineering.

The award, made annually by a committee composed of nine representatives of the Western Society of Engineers and two each from the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E., was established in 1917 by Past-President J. W. Alvord of the Western Society. The 1924 award is the third; the first was made in 1919 to Herbert Hoover, the second in 1922 to Capt. Robert W. Hunt.

Frank Bunker Gilbreth

IN THE sudden death of Major Frank Bunker Gilbreth on June 14, The American Society of Mechanical Engineers has sustained the loss of one of its most versatile and interesting members. With his wide experience in many lines of industry, his keenly analytical mind, his ready wit and wealth of anecdotes, Major Gilbreth has made the Spring and Annual Meetings of the Society, which he seldom missed, events to be remembered by all who came in contact with him. His earnestness in debate in the professional sessions was only equaled by his entertaining reminiscences and love of fun in the more informal gatherings outside of those sessions. His passing leaves a gap that will be difficult to fill.

Of his professional achievements we will speak later. It is concerning his place in the Society that is of interest here. A member since 1903, Major Gilbreth has always been active in its affairs. His progressivism was labeled dangerous radicalism by some of the older members, but it is worthy of note that things that were radical when he first advocated them are commonplaces today in the Society's activities. A single instance may be cited—his work to have management recognized as a major division of engineering.

FRANK B. GILBRETH

Major Gilbreth was profoundly impressed with the principles enunciated by Taylor in his paper on Shop Management in 1903 before this Society. He saw almost instantly that these principles were destined to effect a revolution in industry. He predicted that Taylor would go down in history as one of the world's greatest engineers, and this at a time when a large percentage of his contemporaries regarded Taylor as a dangerous lunatic. Gilbreth joined the small but determined minority fighting to establish those principles as part of the permanent scheme of industry—even to the extent of making them the foundation stones of his own business. When the opponents of Taylor objected to further discussion of his work in the Society, Gilbreth labored long and earnestly to have the decision reversed. When apparently finally blocked he took a radical step, the formation of a society whose chief work would be the promulgation of the principles of management that had by that time become almost a religion to him. The Society to Promote the Science of Management (now the Taylor Society) was conceived and organized by him to do the work that Gilbreth thought would not be done by the A.S.M.E. Yet so hopeful was he that the latter would come to his way of thinking, that he proposed that no one not eligible to membership in the A.S.M.E. could be eligible to the new society, so that at some future time a merger could be effected if desired. In this move he rallied around him such prominent men as Henry L. Gantt, James M. Dodge, and William Kent, whose loyalty to the parent organization could not be questioned.

It was but a few years later that the A.S.M.E. formally recognized management and organized the Management Division. Major Gilbreth accepted membership on the executive committee of that division and labored as hard to make it an outstanding success as he had to bring the Society to his way of thinking ten years previous.

A great achievement to be credited to Major Gilbreth was the institution of the first International Congress on Management, held in Prague, Czechoslovakia, July 20–24 of this year, in which the A.S.M.E. had a prominent part. Much of his work had been in Europe, and since the war he had made several trips to Czechoslovakia. Impressed with the progressiveness of the Czechs, Major Gilbreth suggested to the executive committee of the Management Division the desirability of a meeting in Czechoslovakia to discuss management. He was authorized to confer informally with the Masaryk Academy in Prague, with the result that early this year an invitation was extended through the American Engineering Council to the engineers of the United States to participate in the first international congress of the kind ever held. Major Gilbreth was appointed a member of the Committee on American Participation, which was charged with formulating the program and securing speakers. The success of the Congress was due in no small measure to his untiring work on this Committee. It and the Taylor Society will stand as monuments to his vision.

Frank Bunker Gilbreth was born on July 7, 1868, in Fairfield, Me. He became an apprentice in the building trades, supplementing his work with special courses at the Massachusetts Institute of Technology. Going into business for himself as a contractor and construction engineer, he became nationally known as a builder of big work. Several towns and industrial cities were constructed by him. At this time be began his classic work on Motion Study, and devised many methods of shortening the time of doing work by eliminating useless motions. One instance is the showing of the possibility of reducing the motions of a bricklayer from 18 to 5. It was his motion studies that first brought him in contact with Taylor, with the eventful result that he abandoned the construction field to devote all his time to management, both as a consultant and a research worker.

Major Gilbreth was probably the first to recognize the value of the motion-picture camera as an aid to industry. Conceived first as merely a more accurate method of time study, it soon became evident that as a method of research for the development of fundamentally correct methods in industry it was of the greatest possible value. Major Gilbreth at the time of his death had developed its use for the determination of the "one best way" to such a degree that the accuracy of his predictions of results was almost uncanny. It was as a Major of Engineers during the war that he developed by means of his motion-picture-camera researches methods of training soldiers in the operation of machine guns and similar mechanisms that greatly cut down the time necessary to put men in the field. After the war the same methods were used by him in the rehabilitation of crippled soldiers, and later for the rehabilitation of the industrially crippled.

Major Gilbreth also had done much research in the elimination of fatigue in industry, and had developed many useful inventions for this purpose. In much of his work he was assisted by his wife, Lillian Moller Gilbreth, to whom he invariably gave credit for her part. In fact, of late years all papers and results of researches have appeared as their joint effort.

In June, 1920, Major Gilbreth was awarded by the University of Maine the degree of LL.D. for his work on waste elimination, motion study, and management, and researches in the study of fatigue. In addition to his connection with The American Society of Mechanical Engineers, he was a member of the Providence Engineering Society, the Eastern New York Engineering Society, American Academy of Political and Social Science and an honorary member of the Society for the Promotion of Occupational Therapy.

Major Gilbreth was the author of numeraus works on motion study, waste elimination, and industrial fatigue, among them being: Field System, 1908; Concrete System, 1908; Bricklaying System, 1909; Motion Study, 1911; and Primer of Scientific Management, 1911. As co-author with Mrs. Gilbreth he wrote: Time Study; Fatigue Study, 1916; Applied Motion Study, 1917; and Motion Study for the Handicapped, 1919. He also contributed many papers to the societies of which he was a member and to the technical press.

Engineering and Industrial Standardization

Pan-American Industrial Standardization

IMPORTANT commercial, technical, and trade associations in this country interested in Latin-American commerce were represented at a conference on Pan-American standardization in Boston on June 3. The conference, called upon the request of the Inter-American High Commission and the United States Department of Commerce, under the auspices of the American Engineering Standards Committee, was to enable American industries to arrange for participation in the official Pan-American Congress on Standardization, to be held in Lima, Peru, next November, and to give an opportunity to technical industries of this country to formulate a general policy toward the undertaking.

A message from Herbert Hoover, Secretary of Commerce and President of the American Section of the Inter-American High Commission, outlined the preliminary plans which had already been made for the Lima conference. Proposals looking toward standardization between the republics of North and South America have been submitted many times during the last few decades, most of such propositions coming from the governments of the Latin-American republics. The Department of Commerce and the High Commission already had preparations well under way for the discussion of classification or standardization of several important raw materials, such as cocoa, coffee, rubber, sugar, cotton, and tobacco.

P. G. Agnew, Secretary of the American Engineering Standards Committee, outlined industrial standardization on a national scale as it has developed in sixteen of the leading industrial countries, and the present status of international coöperation in such work.

A paper by J. Hampton Moore, former mayor of Philadelphia, on industrial conditions in Latin America as affecting the problem of industrial standardization was read by A. S. Durrant. Mr. Moore has recently returned from an extensive tour in South America studying industrial conditions. He gave it as his opinion that the extensive classification and standardization of raw materials exported from South America and of manufactured products imported by it would be of great commercial and industrial advantage, both to the Latin-American countries and to the importing and exporting industries of the United States.

Approval was given to a preliminary report on the proposed plan of publishing an English, Spanish, and Portuguese glossary of technical terms which had been prepared by M. H. Bletz, of the Department of Commerce, W. H. Stratton, of the U. S. Steel Products Company, and John Abbink, of the McGraw-Hill Company.

A study of the use of nationally recognized specifications in foreign trade was presented by W. W. Nichols, president of the American Manufacturers' Export Association.

There was not sufficient time to give adequate consideration to the technical subjects to be presented at the Lima conference, consequently this was left to a committee of five to be appointed by the Chairman of the conference.

The general conclusions of the conference were embodied in the following resolutions:

Resolved: That this conference at Boston welcomes the action of the Pan-American Union in calling a conference on Pan-American standardization at Lima next November, as an opportunity to take initial steps of far-reaching importance in the establishment of a sound basis for better and more intelligent Pan-American trade.

Resolved: That this conference accepts the present opportunity of helping to crystallize the sentiment of industry of the United States with regard to problems that will come up for discussion on that occasion and specifically recommends as follows:

1 That each country be encouraged to set up a national standardizing body of the type best fitted to its own requirements.

2 That the American Engineering Standards Committee continue as the national clearing house for standardization in the engineering and industrial fields in the United States.

3 That in developing plans for Pan-American standardization, efforts be made wherever possible to put the movement on a still broader international basis.

4 That the Inter-American High Commission or the Pan-American Union serve as the official channel of communication in this field without the creation of any new international machinery for this purpose.

5 That no effort be made to enforce standardization through legislation or governmental pressure, but that the spread of Pan-American standardization be purely upon a basis of merit and voluntary coöperation.

6 That a committee of five be appointed by the Chairman of the Boston conference to render all possible assistance in the making of detailed preparations in the engineering and industrial field for the Lima conference.

7 That the plan of publishing an English-Spanish-Portuguese glossary of technical engineering terms which are internationally accepted, be approved and that the Chairman of the Boston conference appoint a committee to develop the project to such an extent as to warrant the calling at a later date of a special conference on this particular matter by the American Engineering Standards Committee.

A.E.S.C. Year Book for 1924

THE new year book of the American Engineering Standards Committee has just come from the press and records a marked advance during the past year. This issue comprises 64 pages (8 by 10½ in.), while the 1923 Year Book covered only 48 pages of the same size. The material has been carefully edited and much new and valuable information added.

It is recommended that all of our readers interested in any way in standardization secure a copy for reference. For immediate information, however, we list below the section headings:

1 Summary for Year
2 Industrial Standardization
3 Purpose and Organizations of the A.E.S.C.
4 Method of Work
5 Information Service
6 Membership
7 Relation to Industrial Associations
8 Government Coöperation
9 Coöperation with Foreign Standardizing Bodies
10 Publications
11 Rules of Procedure
12 Constitution
13 Auditor's Report
14 Standardization Projects
15 Coöperating Bodies
16 Statistical Summary
17 Sustaining Members
18 Member Bodies and Representatives
19 Officers and Committees for 1924
20 Alphabetical List of Members and Alternates.

Under the first head will be found two paragraphs of special interest in connection with the growth of the A.E.S.C. They are quoted below:

The growth of the work of the American Engineering Standards Committee is indicative of the growth of the movement as a whole. The number of projects which are under way, or which have been completed and the standards approved, is 152. There are 235 national bodies, technical, industrial, and governmental, coöperating on the work through officially accredited representatives. The number of individuals serving on sectional committees is 1081.

Of the projects which have reached an official status, 31 have to do with civil engineering and the building trades; 25 with mechanical engineering; 15 with electrical engineering; 4 with automotive subjects; 11 with transport; one with ships and their machinery; 14 with ferrous metals; 15 with non-ferrous metals; 12 with chemical subjects; 2 with textiles; 5 with mining; 5 with the wood industry; 1 with the paper and pulp industry; and 11 projects with topics of a miscellaneous or general character.

The second section contains an excellent statement of the many and various advantages of industrial standardization. It reads as follows:

The important role which standardization plays in industrial evolution and its economic and social potentialities are only beginning to be generally understood. Among the many important advantages of standardization are that: it simplifies manufacturing processes; it stabilizes production and employment, since it makes it safe for the manufacturer to accumulate stock during periods of slack orders, which he cannot safely do with an unstandardized product; it lowers cost to the public by making mass production possible it enables buyer and seller to speak the same language, and makes it possible to compel competitive sellers to do likewise; it reduces selling cost; it stimulates research and makes for the elimination of antiquated methods and products; and by concentration on essentials, and the consequent suppression of confusing elements intended merely for sales effect, it helps to base competition squarely upon efficiency in production and distribution and upon intrinsic merit of product.

Throughout the book many improvements in the selection of type and the arrangement of material will be noted. This is true especially of Section 14, entitled Standardization Projects.

The Statistical Summary quoted below gives full evidence of the strength and usefulness of the A.E.S.C.:

Member Bodies—organizations or groups of organizations whose representatives form the A.E.S.C.	23
National organizations included in the Member Bodies	34
Representatives forming the Main Committee	57
Standards approved to April 1, 1924	53
Standards up for approval by the A.E.S.C. on April 1, 1924	35
Projects having official status (already approved, or on which work is under way)	152
Projects for which sponsorship has been accepted	112
Organizations acting as sponsors for projects	56
Trade, technical or governmental bodies coöperating through representatives on special or sectional committees	316
Individuals on sectional committees	1081

The new section on Sustaining Members lists 229 firms who are now contributing annually to the suppport of the A.E.S.C.

Reference to Industrial Standards in Advertising

AS A DEFINITION of policy in the use of references in advertising matter to standards approved by, it the American Engineering Standards Committee has issued the following:

Resolved: That in the opinion of the American Engineering Standards Committee the use, in the advertising of products which comply with specifications and other standards approved by the Committee, of proper references to such standards, is advantageous and makes for industrial economy; accordingly, the Committee desires to encourage the use of such references in trade catalogs and other advertising media, but the Committee will in no case pass upon the merit of products, or upon their compliance with specifications or other standards, which questions it will leave to the commercial and legal agencies equipped for such work.

Extensive use of such references is being made by foreign manufacturers in advertising products made in accordance with the standards of their national standardizing bodies, particularly in Great Britain and Germany. Both the British and Canadian associations have adopted official trademarks for use on goods manufactured in accordance with their specifications.

Specification for Cast-Iron Pipe

AT A CONFERENCE in New York on June 5 it was decided that there should be undertaken a general program of unifying existing specifications for cast-iron pipe into a consistent set of nationally recognized specifications.

Consideration of the subject was introduced by a comprehensive paper by W. G. Hammerstrom, which outlined the present practice, not only of various organizations who have issued formal specifications, such as the American Water Works Association, The American Gas Association, and the American Society for Testing Materials, but indicated the more usual commercial departures from and extensions of these standards. Mr. Hammerstrom also outlined the foreign practice, with particular reference to the work of the British, French, and German cast-iron-pipe industries.

After a thorough discussion of the various problems concerned in the proposal to bring about national uniformity in the industry, agreement was reached on the following scope for this work:

Unification and development of specifications for cast-iron pipe, including: materials; dimensions; pressure ratings; methods of manufacture, including such new developments as centrifugal casting, in so far as they may be necessary to secure satisfactory results in preparation of workable specifications; elimination of unnecessary sizes and varieties; consideration of the possibility of developing a coördinated scheme of metallic pipe and fittings applicable to all common mediums (possibly along the lines of the work being carried on in Europe on the same subject); and methods of making up joints in so far as they are determining as to the dimensional design of cast-iron pipe.

The types of cast-iron pipe under standardization are to include:

a Flanged pipe
b Flanged and bell-mouth fittings and wall castings
c Pipe elbows, tees, Y's, return bends, and other fittings not now included in standard lists
d Cast-iron pipe threaded for flanges or couplings
e Soil pipe and other light types of cast-iron pipe and fittings.

The work will be coördinated with that of the existing sectional committee on pipe flanges and fittings, which is already well advanced under the sponsorship of The American Society of Mechanical Engineers, the Manufacturers Standardization Society of the Valve and Fittings Industry, and the Heating and Piping Contractors National Association.

It was recommended that the work be carried out by a sectional committee under the auspices and procedure of the American Engineering Standards Committee, and under the joint sponsorship of the American Gas Association, the American Water Works Association, and the American Society for Testing Materials, and formal recommendations to this effect were made to the A.E.S.C. At its meeting on June 12 the A.E.S.C. formally ratified the recommendations of the Conference, and designated the three organizations named as joint sponsors for the work.

The conference presented a true cross-section of the American cast-iron-pipe industry, the men present serving as representatives of practically every organization concerned in the subject.

Standardization of Electric Motors for Use with Machine Tools

THE National Machine Tool Builders' Association has formally proposed to the American Engineering Standards Committee that there should be standardization of important dimensions of electric motors for use on machine tools. In presenting the recommendation to the A.E.S.C., E. F. DuBrul, general manager of the association, stated:

At the last meeting of the Board of Directors of this Association, held on May 23, it was brought out that there should be some standardization of the dimensions of electric motors applied to machine tools. The Board thereupon duly voted that we take up this question with the American Engineering Standards Committee, and ask that such standardization be initiated. In general, I might say that great loss is caused to users of machine tools by the present lack of dimensional standardization, particularly in the distance between the motor feet, both longitudinally and laterally, and also the height of the motor shaft from the bottom of the feet.

We feel that this distance could and should be standardized for motors of a given rating so that the same base plates could be provided regardless of the make of motor. The number of revolutions being standardized, this dimensional standardization should to our minds, present no more grave difficulties.

Investigation in Heat Transmission

THE National Research Council through its Division of Engineering has been requested to undertake investigations in heat transmission, the results of which will provide the designing, operating, and research engineer with reliable information.

In accordance with its usual custom, the Division of Engineering will, through a suitable committee, make a careful digest of the available information on the subject, published and otherwise, and prepare a critical summary of these data. This summary will serve the two-fold purpose of giving the industry a concise statement of the best existing information and enabling the Committee to draw up a program of needed investigations.

The problem of heat transmission is so broad and concerns so many fields of engineering, as, for example, refrigerating, heating, electrical, ventilating, automotive and mechanical, that it is necessary to subdivide the work among suitable sub-committees. The entire project will be administered by a small executive committee with the following officers: W. H. Carrier, Chairman, T. S. Taylor, Vice-Chairman, and H. Harrison, Brunswick-Kroeschell Co., 30 Church Street, New York, Secretary. The following sub-committees have been appointed:

Heat Transfer, Fluids to Solids	Nomenclature and Definitions
Heat Transfer, Insulation	Temperature Measurements.

The sub-committee chairmen are now at work completing the organization of their committees, after which the work will be subdivided and assigned to appropriate individuals. Critical reviews will be prepared in each specific field which will include a condensed statement of present knowledge, a program of investigations that are needed to secure additional information, and a budget for conducting these investigations, including the assignment to appropriate individuals and laboratories. These reports when completed will be published in the journals of the engineering societies most interested.

Library Notes and Book Reviews

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Manufacturers Support the Engineering Library

THE gratifying increase in the use made of the Engineering Societies Library has brought embarrassment as well as pleasure to its management, for the difficulty of maintaining it on an adequate scale has been increased greatly by its widening activities.

The chief support of the Library comes from the Founder Societies, the four national societies of civil, mining, mechanical, and electrical engineers. These societies are not able to increase their appropriations as rapidly as the demands on the Library increase.

As much of the increased use of the Library is due to the enlarged interest of the industrial world in research, the situation of the Library was brought to the attention, early this year, of some of the industrial concerns that are making use of it. Many of them have immediately recognized the value of such a storehouse of information to their engineers and research workers and the advantages of keeping its equipment complete. Subscriptions have been received from a large number of important companies and others have the matter under consideration.

At the last meeting of the Library Board, the following resolution of thanks was adopted.

> WHEREAS: In accordance with the instruction of the Board, the secretary has written to a number of prominent organizations which have used the Library and its service, and asked for contributions toward its maintenance, and
>
> WHEREAS: Many organizations have contributed and others, we are advised, are giving consideration to the matter; therefore be it
>
> *Resolved:* That the hearty thanks of this Board be extended to those organizations that are enabling it, by their generous contributions in response to its statement of the condition of the Engineering Societies Library, to maintain the resources of the Library on a plane adequate to their needs for service.
>
> HARRISON W. CRAVER,
> *Director, Engineering Societies Library*

Tales of Invention

POPULAR RESEARCH NARRATIVES. Fifty tales of research, invention, and discovery collected by the Engineering Foundation. Williams and Wilkins Co., Baltimore, Md., 1924. Cloth 5 × 7¼ in., 152 pp. $0.50.

AN INTERESTING and human record of scientific achievements has recently appeared in a little book of popular research narratives collected by the Engineering Foundation. These narratives, which appeared originally in periodical form, cover widely different subjects in engineering and science and are prepared with due appreciation of the technical elements involved but in a manner that is readily understandable by any one who has had the fundamentals of a technical education. They are worth-while. The first fifty narratives of the series are included in this little volume. Later accumulations will be published in a similar manner.

Books Received in the Library

ALIGNMENT CHARTS FOR ENGINEERS AND STUDENTS. By W. J. Kearton and George Wood. Charles Griffin & Co., London; J. B. Lippincott Co., Philadelphia, 1924. Cloth, 6 × 9 in., 220 pp., diagrams, charts, $6.50.

A textbook for students of nomography and a reference book for engineers. The authors first discuss at length the principles that underly the construction and operation of nomograms, then give directions for the practical construction of them. A series of diagrams showing the arrangement of lines for equations with from three to six variables is given. Nearly one-half of the book is occupied by a collection of thirty-five charts which represent some of the more important formulas used in various branches of engineering. These include charts for the strength of cylinders and shafting, of circular flat plates, of gearing and of springs; for the flow of water in pipes and through orifices, for earth pressures on walls, etc.

BERICHTE DES VERSUCHSFELDES FUR WERKZEUGMASCHINEN AN DER TECHNISCHEN HOCHSCHULE BERLIN, Heft 6: Forschung und Werkstatt II. By Georg Schlesinger and others. Julius Springer, Berlin, 1924. Paper, 10 × 13 in., 31 pp., illus., diagrams, $0.60.

The three papers contained in this pamphlet give the results of investigations undertaken in Germany during the war, with the object of discovering the most satisfactory substitutes for unobtainable materials. The first deals with the suitability of various kinds of woven belting as substitutes for leather and describes methods and apparatus for testing. The second is an investigation of the effect of lubricants on drilling. The third gives the results of experiments with bearings made of zinc alloys containing but little copper. The investigations were made in the Machine Tool Research Department of the Berlin Technical High School.

DEVELOPMENTS IN POWER STATION DESIGN. By Edwin Austin. D. Van Nostrand Co., New York, 1924. Cloth, 8 × 11 in., 271 pp., illus., diagrams, $9.

Present interest in more efficient utilization of national power resources is the reason for the publication of this book, which is based on a series of articles that appeared in *The Engineer* during 1921 and 1922. The author describes modern power-plant practice in Great Britain and elsewhere, paying particular attention to the devices and methods that promise great efficiency. The account is descriptive, rather than technical, and is intended primarily for those connected with large public electric plants. It is based on personal visits to power plants and on information obtained from specialists.

DYNAMICS. By Horace Lamb. Second edition. England, University Press Cambridge, 1923. Cloth, 6 × 9 in., 351 pp., 12s 6d.

A textbook forming a sequel to the author's Statics, the two giving a thorough introduction to mechanics. The present edition has been revised, some pages rewritten and new exercises added.

ELEMENTS OF STEAM AND GAS POWER ENGINEERING. By Audrey A. Potter and James P. Calderwood. Second edition. McGraw-Hill Book Co., New York, 1924. Cloth, 6 × 8 in., 339 pp., illus., diagrams, $2.75.

A brief textbook for students in engineering schools. Intended to familiarize them with power-plant equipment before they study thermodynamics and design. Should also interest those who are responsible for the operation of power plants, as it presents the principles that underly the construction and operation of steam and gas power equipment clearly and concretely. Chapters on the locomotive and automobile are included.

ENGLISH INDUSTRIES OF THE MIDDLE AGES. By L. F. Salzman. Clarendon Press, Oxford, England, 1923. Cloth, 5 × 8 in., 360 pp., illus., $3.50.

This interesting account of the industries of medieval England

is not a complete history but an introduction to the subject. It is intended for the general reader, interested in English history, rather than technologist, but will not be devoid of interest to the latter. The leading medieval industries, mining, quarrying, building, metal working, pottery, weaving, leather working, fishing and brewing are treated; their centers, development and methods being shown for the period which is approximately the sixteenth century. The illustrations are from medieval sources.

HAND-BOOK OF FIRE PROTECTION. By Everett U. Grosby, Henry A. Fiske, and H. Walter Forster. Seventh edition. D. Van Nostrand Co., New York, 1924. Fabrikoid, 5 × 7 in., 899 pp., illus., diagrams, $4.

This handbook affords to students of the subject a concise, reliable account of approved practice. The general causes of fire and the special hazards of various industries are explained, the spread of fire and the lessening of danger by structural means are discussed, special information being given on proper construction for special purposes. Another section treats in detail of public and private equipment for extinguishing fires. Many useful tables and minor articles are included.

HUTTE DES BAUINGENIEURS. By Akademischer Verein Hutte. Wilhelm Ernst & Sohn, Berlin, 1924. Cloth, 5 × 7 in., 1340 pp., diagrams, tables, $3.30.

This is a separate issue of the third volume of the twenty-fourth edition of the well-known pocket-book, Hütte. Arrangements are now made to sell the separate volumes separately and the present volume appeals particularly to the civil engineer. The book is divided into seventeen sections, treating of surveying, statics, earthwork, reinforced concrete structures, steel structures, heating and ventilating, factory buildings, building machinery, hydraulic engineering, hydraulic power plants, dams, highway engineering, city planning, water supply, sewerage engineering, railroads and bridges. Each section is the work of a specialist. The entire work has been revised and many sections rewritten.

LIGHT AND WORK. By M. Luckiesh. D. Van Nostrand Co., New York, 1924. Cloth, 6 × 9 in., 296 pp., diagrams, plates, tables, $4.

The aim of this book is to analyze natural lighting, to point out its important fundamentals, to suggest improvements, to reveal the relations between lighting and vision, and to show the economic results from adequate proper lighting, measured in increased safety, efficiency and happiness. These discussions summarize the results of many researches in the laboratory and in practice, which are of interest to lighting specialists, engineers, and employers.

MANUAL OF ENGINEERING DRAWING. By Thomas E. French. Third edition, revised and enlarged. McGraw-Hill Book Co., New York, 1924. Cloth, 6 × 9 in., 409 pp., illus., diagrams, $3.

This is a textbook with a collection of tested problems, grouped and graded, and following current engineering practice. This new edition has been thoroughly revised and new problems and text added. The new matter includes chapters on Working Drawings, Perspectives and Charts.

MARINE ENGINEERING PRACTICE. By F. J. Drover. D. Van Nostrand Co., New York, 1924. Cloth 5 × 9 in., 494 pp., illus., diagrams, $6.50.

Covers marine boilers, oil burning, steam engines and turbines, oil engines and auxiliary machinery. The book is confined to machinery and apparatus in use at present, and is intended as a guide to its operation and maintenance which will be practical and useful to students and operating engineers.

MECHANICAL REFRIGERATION. By Hal Williams. New and enlarged edition. Isaac Pitman & Sons, London and New York, 1924 Cloth, 6 × 9 in., 501 pp., illus., diagrams, tables, $6.

Written from the viewpoint of the owner, manager and student, rather than from a purely technical one. Discusses the general principles involved, the historical development, the properties of the usual refrigerants, the types of machines in use, the refrigerating plant, and the auxiliary plant. Chapters are devoted to insulation and brine. The application of refrigeration for making ice, for cold storage and for other purposes is described, and there is a special chapter on the cold storage and packing of meat.

MODERN EXECUTIVE. By Daniel Bloomfield. H. W. Wilson Co., New York, 1924. (Modern executive's library.) Cloth, 5 × 8 in., 266 pp., $2.25.

This volume contains papers by various writers which have appeared in magazines in recent years, dealing with the duties of the executive and the recognition and development of executive ability. The articles are by experienced executives. They show what is expected of the executive and indicate ways of attaining efficiency.

POPULAR RESEARCH NARRATIVES. Collected by the Engineering Foundation. Williams & Wilkins Co., Baltimore, Md., 1924. Cloth, 5 × 8 in., 152 pp., portraits, $0.50.

Accounts of many important modern inventions and discoveries are included in this volume of concise essays, which is issued primarily to show the value of systematic scientific research to the world. The stories are written for laymen, in simple language. Based on information from the investigators themselves, they are accurate.

REINFORCED CONCRETE AND MASONRY STRUCTURES. By George A. Hool and W. S. Kinne. McGraw-Hill Book Co., New York, 1924. Cloth, 6 × 9 in., 786 pp., illus., diagrams, tables, $6.

The topics covered in this volume include the preparation and placing of concrete forms, bending and placing reinforcement, finishing and waterproofing, building construction, retaining walls, slab and girder bridges, arches, hydraulic structures, chimneys, detailing and estimating. The book is the work of a number of specialists, who have combined to produce a thorough description of modern methods of design and construction, suited for use as a reference book by students and engineers.

RESEARCH INFORMATION SURVEYS ON CORROSION OF METALS, Nos. 4–6; Zinc, Tin, Lead. By Harold F. Whittaker. National Research Council, Research Information Service. Washington, D. C., 1924. Paper, 8 × 11 in., mimeograph form, various paging, $2.

The second series of research information surveys on corrosion provides valuable surveys of our present knowledge of the effect of various corrosive agents on zinc, tin, and lead, and of methods for preventing corrosion. Good bibliographies are provided, so that the surveys answer all ordinary requirements of investigators.

REPRESENTATIVE GOVERNMENT IN INDUSTRY. By James Myers. George H. Doran Co., New York, 1924. Cloth, 5 × 8 in., 249 pp., illus., $2.

The writer of this book has attempted to show how employee representation works in factory management, to explain in detail the technique necessary for success and to analyze the economic, social and moral factors that affect the operations of works councils. The author is executive secretary of the board of operatives of the Dutchess Bleachery, Inc., where employee representation is used.

STORAGE BATTERIES. By George Wood Vinal. John Wiley & Sons New York, 1924. Cloth, 6 × 9 in., 402 pp., illus., diagrams, tables, $4.50.

Although there is considerable literature on storage batteries, most of it is scattered and a book that summarizes the physical and chemical facts about them and describes their applications, is very desirable. The present book presents the scientific principles that underly the operation of storage batteries and gives a detailed description of the essential processes of manufacture, paying especial attention to the electrolyte. It then discusses operation, including charging, discharging, regulation, operating costs and troubles. There are also chapters on testing and on various applications and the appropriate batteries for it.

VORTRAGE AUS DEM GEBIETE DER HYDRO- UND AERODYNAMIK. By Th. v. Karman and T. Levi-Civita. Julius Springer, Berlin, 1924. Paper, 6 × 9 in., 251 pp., diagrams, $3.10.

Contains the twenty-four addresses and papers presented to an informal conference of students of hydromechanics and aeromechanics, which was held in Innsbruck in September, 1922. These papers are chiefly concerned with the mathematical consideration of some of the theoretical problems which are at present engaging the attention of investigators, and which have practical interest for engineers engaged in hydraulics and in aviation.